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REQUIRED. State size and full particulars equipment and price required.—Address, S 959, Offices of ENGINEERING.

Wanted, Two Pumps, Steam-

driven, reciprocating, and Two Motor-driven Turbine type. Steam pressure 100 lb. sq. in. Direct current 250 volts. Capacity 10,000 galls. hour each at 160 lb. sq. in. for reciprocating and 10,000 galls. per hour each at 100 lb. or 160 lb. sq. in. for turbine. State full particulars, maker's name and place of inspection.—Address, S 957, Offices of ENGINEERING.

Second-hand. — About 200

yards TRACK, with pressed steel sleepers, trough section, ready for laying. Steel Rails 14–16 lbs. per yard.
TWO TURNTABLES.
FOUR WAGONS, Jubilee Type, double side tipping, 12 in. wheels, capacity 1 cubic yard, also
TWO JUBILEE TYPE END TIPPERS, 1 cubic yard capacity.
All to be for 2 ft. Gauge.—Replies to be sent to the MANAGER, BROADSTAIRS GAS COMPANY. S 934

URANIUM AND ITS METALLURGICAL APPLICATIONS.

THE element uranium belongs to that rare but extremely useful group of metals of which tungsten, molybdenum and vanadium are perhaps the best known. Only in comparatively recent years have these elements found extensive use; their former employment was restricted to the use of a few of their compounds as laboratory re-agents, and a small number of quite minor uses. As for uranium itself, it remained little more than a chemical curiosity until it suddenly came into the limelight by the discovery of its radioactive properties, and its relation to radium and helium. This discovery, while profoundly influencing the conceptions of the atom and the theories regarding the earths' internal heat, is a phase of the properties of uranium which has been adequately dealt with in technical literature during recent years. The purpose of this article is chiefly to describe the mode of occurrence of uranium ores, the isolation of the element from such ores, and the industrial uses of the metal apart from those arising out of the radio-active properties. Nevertheless, a few brief references to these latter properties must necessarily be made to make clear the metallurgy of the extraction of uranium from the complex ores containing it, because the methods adopted are to a large extent dependent upon the recovery of the radium contents of all uranium ores. It is now a well-known fact that given the presence of uranium in an ore, radium will also be present in a certain ratio of the uranium content, the degree of radioactivity is thus not only a guide to the radium content, but likewise to that of the uranium.

With regard to the physical and chemical properties of uranium, it is a lustrous silver-white metal with an atomic weight of approximately 239. It is thus the heaviest of all known elements. The density of uranium is 18·7, which is only exceeded by the densities of gold, platinum and the other metals of the platinum group. Uranium metal melts at about 1,800 deg. C., but although the melting-point considerably exceeds that of iron, uranium is much more volatile at high temperatures.

The metal is unattacked by air at ordinary temperatures, but burns brilliantly in air at a temperature of 170 deg. C., and emits copious sparks when struck with a hard substance. This latter property has given it a limited application for making automatic lighters. The metal decomposes in boiling water forming the hydrated oxide, and it also dissolves freely in most mineral acids and in a few organic acids to form salts of the metal; the best known salts are the nitrate and acetate used as laboratory reagents. The salts are remarkable for their extreme flourescence, and certain of these are used in the dyeing of silk. The oxide is used for making a canary-yellow glass with a green reflex capable of rendering visible, objects illuminated by ultraviolet rays.

The ores of uranium are found in only a few parts of the world, and the chief occurrences are at Joachimsthal in Bohemia, Johanngeofgenstadt in Saxony, in Paradox Valley and other parts of Colorado, and in Utah.

Ores of uranium are never abundant, and the uranium content of such ores rarely exceeds 2 per cent. or 3 per cent. The ore minerals are practically restricted to three, namely, pitchblende, which is an amorphous mineral containing uranous and uranic oxides associated with a number of other metallic oxides; uraninite, which is a crystalline variety of pitchblende; these are both primary minerals and usually occur as constituents of veins with an exceedingly complex mineralisation genetically connected with granite or pegmatite intrusive rocks. Sometimes the minerals are found as disseminations through, or impregnations in, the igneous rocks. Another important uranium ore mineral, which is also an ore of vanadium, is carnotite. This is essentially a hydrous potassium uranium vanadate; it is considered to be secondary, and it is found in belts in porous sedimentary rocks such as sandstones.

A few of the more important occurrences of uranium minerals may be very briefly described:—In certain parts of Cornwall where granite batholiths have intruded various sedimentaries, there are lodes containing cassiterite and copper minerals cut by veins carrying cobalt, bismuth and other minerals with pitchblende in association with them.

In the Erzegebirge, which is a range of mountains dividing Bohemia and Saxony, sedimentary and metamorphic rocks are intruded by granite, granite porphyry and quartz porphyry. Associated with the granitic intrusions are veins of various types of mineralisation, some carrying tin, others lead and zinc, or cobalt, nickel and silver. Locally these minerals are associated with pitchblende or uraninite in sufficient quantity to make otherwise low grade ores profitable to mine. There are at least three localities in this region where uranium minerals are being mined at present, or have been mined in recent years.

At Joachimsthal on the Bohemian side of the Erzegebirge, the pitchblende ores are associated with quartz, dolomite, pyrite and chalcopyrite, and, locally, pitchblende coats nickel and cobalt minerals in the veins of this locality. At Annaberg on the Saxony side of the mountains, pitchblende is found in veins coating siderite and fluorspar in the nickel-cobalt mineralisation of these veins. These veins cut older cassiterite veins. At Johanngeorgestadt, also in Saxony, pitchblende veins cut bismuth-silver veins, and pitchblende is often found enclosing galena, chalcopyrite and bismuth.

The uranium mineral mined in Colorado and Utah in the United States, is carnotite. It occurs as impregnations in fairly coarse cross-bedded sandstones of Jurassic age, either as an amorphous dusty coating on, or matrix between, grains of sand. Occasionally it coats the rock along joint-planes and fractures and fills openings caused by rock movements.

The carnotite deposits are small and lenticular, and conform to the bedding planes of the rock. The mineral gives a canary-yellow colour to the rock, except when the vanadium constituent predominates when the rock is coloured brown or black. The ore bodies are rarely more than 100 ft. in lateral extent, and vary from a few inches to several feet thick. While carnotite ore beds are superficial, they are not easily located because of their inconspicuous character. It is usual to prospect a likely locality by the prospecting drill, and by this method many important ore bodies have been disclosed in Colorado in recent years. Doubtless a considerable number of hidden deposits still await discovery in this region.

The separation of uranium from its ores is a costly and complicated process because of the refractory character of these ores. But the ores are seldom treated only for their uranium content. Indeed, this is more often a by-product of the recovery of radium or vanadium, or both, and thus the cost of treatment is shared between two or more products.

The most usual method of treatment is a wet one, because this kind of process is the most satisfactory for the recovery of the contained radium. The crushed ore is boiled in hydrochloric acid in earthenware vessels until the soluble matter, including the uranium and radium, is taken into solution. To the filtered solution, a little barium chloride is added, and then sufficient sulphuric acid to precipitate the barium and radium as insoluble sulphates. The uranium and other metallic constituents of the solution are precipitated on scrap iron, and from these mixed metals the uranium can be separated by boiling water which decomposes the uranium but not the other metals. A flocculent hydrated oxide is thus obtained which is separated from the other unchanged metals without special difficulty.

The method adopted at Joachimsthal is a furnace one, and consists of roasting the ore to expel sulphur and arsenic, and smelting the mixed oxides thus obtained with a limited amount of carbon in an electric furnace. Under these conditions, metallic copper, lead, iron and nickel are formed, and a slag which contains the lower oxides of uranium, vanadium, tungsten and molybdenum, or such of them as may be present.

The reduced metals are drawn off, and the slag is heated further in the same furnace with additional carbon. After heating for a sufficient time, the oxides are converted into carbides and these, on being treated with water remain unchanged, except the uranium carbide. This is decomposed, and forms a flocculent hydrated oxide which is readily floated off and separated from the unaltered carbides. This material is dried, calcined, and then either converted into ferro-uranium by a crucible method or reduced to uranium metal by the "thermit" method of reduction.

The methods employed for production of ferro-uranium do not materially differ from those used in the production of other ferro-alloys, but because of the tendency of uranium to volatilise, greater care is necessary. A crucible method which has recently been suggested is the mixing of iron turnings with uranium fluoride and fusing these at a white heat in an ordinary clay crucible in a gas-fired furnace. This is said to give a satisfactory product, and appears to be a simple and economical method of making small quantities of the ferro-alloy.

The average annual production of uranium is not officially recorded, but it is doubtful if it greatly exceeds the equivalent of 100 tons of uranium metal. Only the Joachimsthal and United States deposits yield appreciable quantities, and of these the latter are by far the most important. The United States production for the three years ending December 31, 1918, has been estimated as follows:—

Year.	Short Tons of Ore.	Tons of Uranium.	Grammes of Radium.
1916	20,300	33·7	10·0
1917	33,404	87·4	26·4
1918	18,860	89·5	27·1

The greater portion of this production is used for alloying with steel for which, owing to the small proportions used, it is sufficient to produce several thousand tons of uranium steel.

Uranium imparts remarkable physical properties to steels and alloys. When added to steels, it does not need to be augmented or intensified by the addition of other constituents, as is the case with some other steel-alloying elements. It increases the hardness and hardening power of steels by reason of its ability to emphasise the characteristics of cementite; the hardness imparted thereby is not accompanied by the brittleness that is characteristic of other carbide-forming alloys. As a substitute for tungsten in special alloy steels it is claimed that a small proportion of uranium is equivalent to a relatively large proportion of tungsten.

Uranium steels are pre-eminently adapted for uses necessitating a low drawing temperature in that they possess under these conditions a remarkable combination of hardness, strength and durability.

The effect of the addition of small amounts of uranium on the physical properties of alloy steels is shown by the results (see Table I) reported by H. S. Foote in a recent issue of *Chemical and Metallurgical Engineering*, on different classes of alloy steel and compared on a like basis of ductility.

TABLE I.

Composition.	Elastic Limit.	Tensile Strength.	Elongation per Cent.	Reduction in Area.
C, 0·32; Ur, 0·22 ..	154,800	162,000	15·5	59·3
C, 0·30; Ni, 0·22 ..	111,000	124,000	15·5	53·0
C, 0·31; Cr, 0·39; Va, 0·16	146,200	162,700	15·0	57·0
C, 0·28; Cr, 0·85; Mo, 0·37	154,000	165,000	15·0	58·3

These figures show that a small percentage of uranium increases the elastic limit and tensile strength to a point comparable with those of more complex alloy steels.

But while uranium alone in carbon steels produces results as shown, it also intensifies the desirable properties in the more complex steels. Foote supplies data of tests on uranium-nickel steels of the following percentage compositions which illustrate this fact: (*a*) C, 0·39; Ur, 0·22; Mn, 0·60; Si, 0·20; Ni, 3; quenched in oil from 1,425 deg. F. (*b*) C, 0·45; Ur, 0·29, Mn, 0·48; Si, 0·53; Ni, 3; quenched in oil from 1,475 deg. F. These tests are recorded in Table II, page 842, and it is interesting to note that the combination of small amounts of uranium with nickel produces a steel in which the desirable effects of both alloying elements are magnified. Many other examples might be supplied, but those

given show that in alloy steels containing a little uranium, there is a material of extraordinary physical properties which for certain special purposes cannot be replaced by any other material equally suitable.

Table II.

Elastic Limit.	Tensile Strength.	Elongation per Cent.	Reduction in Area.	Brinell Hardness.	Drawing Temperature.
(a) 206,400	248,600	13·0	47·7	512	400
(b) 244,500	290,100	10·0	29·1	555	—
(a) 199,200	231,100	13·5	51·1	477	500
(b) 238,900	271,100	10·5	35·5	512	—
(a) 183,300	202,100	13·5	54·1	418	600
(b) 212,000	228,000	11·0	30·0	464	—
(a) 164,100	177,200	15·0	56·0	387	700
(b) 185,000	198,200	12·0	45·0	415	—

(a) Charpy test, 156 ft.-lb. per square inch.
(b) Charpy test, 73·8 ft.-lb. per square inch.
(a) Alternating impact, 934 blows (⅛ in. throw).
(b) Alternating impact, 900 blows (⅛ in. throw).

As a constituent of high-speed tool steels, uranium has been found to be of great value. A metallographic study of high-speed steels indicates that the uranium tends to promote the formation of complex carbides upon which are dependent the cutting efficiency and the property of "red hardness" A complex uranium carbide is apparently more soluble in gamma iron than the carbides ordinarily found in high-speed tool steels, and it is reasonable to infer that uranium exerts an important influence on the property of "secondary hardness."

While the valuable properties of uranium steels have come to be widely appreciated, the relative scarcity of the ores of uranium limits the quantity of such steels that can be produced, and makes it improbable that the metal will ever be cheap enough to compete with other more abundant steel-alloying elements. But it may be taken that certain exclusive properties, some already known and others that await discovery, will ensure its industrial employment, irrespective of the cost of the production of the metal. Moreover, the ores of uranium might prove to be much more abundant than they now appear to be. Many parts of the world have never been explored for uranium minerals, and other parts only very partially. During the last few years most of the United States deposits have been discovered, and only quite recently, reports have reached this country of the presence of uranium minerals in some abundance in the richly mineralised Katanga region of the Belgian Congo.

THE MOVING OF BRICK BUILDINGS.

Most people in this country are familiar with stories from the United States of the moving of complete buildings, but few realise the extent to which this practice has actually developed over there, and most are satisfied to believe that such operations are commonly confined to wood frame buildings which have some quality of elasticity. That success in this class of work is not dependent upon characteristics of this type must be realised when it is stated that numerous cases have occurred in which the removal of buildings of a permanent type have been very successfully handled. Not only have large steel-frame and concrete buildings been removed and re-sited, but brick buildings, both plain and of steel frame structure have been similarly treated without any damage. The work is of a very special nature in which undoubtedly wide experience must contribute greatly to success.

One of the firms specialising in this class of work is the John Eichleay, Junior, Company, of South Twentieth and Wharton-streets, Pittsburgh, Pennsylvania, to whom we are indebted for particulars of two very interesting jobs which they have recently completed. The moving work accomplished by this firm has been of a very varied nature, and before dealing with the two cases selected, in detail, we may fittingly touch briefly on some of the other instances in which considerable saving has been introduced by moving instead of pulling down and rebuilding. In several cases the removal has been necessitated by road widening operations, in others it has been made advisable on account of rearrangement of plant, and in others by special circumstances, as, for instance, the need of raising buildings to get above flood levels, and so on. The latter cases have not always involved moving in addition to raising. As an example of the first class, of moving necessitated by road widening, we may quote the case of a brick building at New Haven, Conn., 36 ft. deep back to front, and 192 ft. in length. This building was partly of two stories and partly of three stories. It was the Y.M.C.A. of the New York, New Haven and Hartford Railroad. It was successfully lifted, moved 70 ft. away from its old site and turned through 45 deg. In another case two business buildings standing side by side and joined together by the party wall, were moved intact at Youngstown, Ohio. In this instance the two buildings together had a frontage of 120 ft., and were 80 ft. deep front to back. They stood on Federal-street and were moved back as one unit a distance of 17 ft. Business proceeded as usual during the move. A brick building of a much more ornate type of architecture, weighing about 2,500 tons was moved at Glen Falls, New York, in the case of the Glen Falls Insurance Company's offices, which were removed to a new site 500 ft. distant, to make room for a larger office building on the old site. This building was of brick with ornamental stone string courses, and tile roof. It measured about 65 ft. by 110 ft., and was removed across the street which it faced and turned half round, so as to face in the opposite direction. The railway station of the Southern Railway Company, at Danville, Va., a long brick building with a central brick tower, was removed to a new location on account of alterations to the tracks. It was raised 5 ft., turned through 45 deg., moved 200 ft. sideways and 60 ft. lengthwise, and successfully placed on new foundations.

In the re-location of plant owing to expansion and rearrangement of works a larger number of interesting cases might be cited in which moving has not only proved less costly than rebuilding, but in which in many cases special plant has been got to work again more quickly than could have been hoped for if reconstruction had been adopted. The Aluminium Rolling Mill Company, of Cleveland, Ohio, in the reorganisation of their mills had two steel-frame buildings each 200 ft. long by 90 ft. wide, moved 1,000 ft. to a new location, turned through 90 deg., and placed end to end, and an additional bay added. At the rebuilding of the factory and warehouses of Messrs. H. J. Heinz and Co., in Pittsburgh, the complete reconstruction scheme included a new building of larger and more pretentious character on the site occupied by a two-

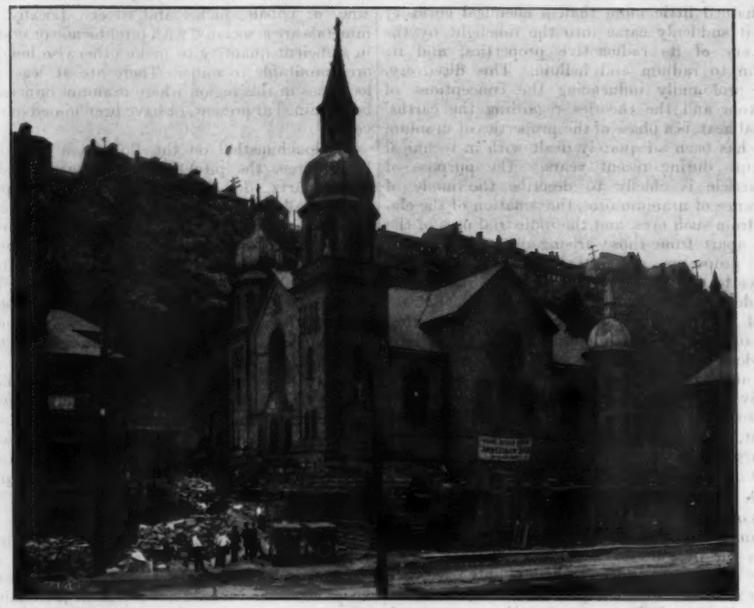


Fig. 1. St. Nicholas R. C. Church, Pittsburgh, Raised and on the New Site.

Fig. 2. Arrangement of Cribbing, &c., Used for the Move.

story brick warehouse, 92 ft. wide by 140 ft. long. This building was accordingly raised and moved 250 ft. across Progress-street, to a new site on River-avenue, to make way for the completion of the reconstruction scheme.

We might cite several other cases of equally successful work, which it will be recognised requires a vast amount of preparation, and which is greatly complicated when the buildings have to be turned in the process of moving. Messrs. Eichleay, however, seem to have been most successful in this class of work from the long list of large jobs they have safely accomplished.

The two examples we now propose to refer to have been carried out quite recently. The first is illustrated in Figs. 1 to 5, on the opposite and present pages. The building was the Roman Catholic Church of St. Nicholas, on East Ohio-street, Pittsburgh. It was necessary to move this building back from its original position a distance of 20 ft., but as the building stood against a steep hillside, it was also necessary to excavate behind it something like 3,000 cub. yards of earth. This was done by a steam shovel. The building is of brick without frame work of any kind. It is 110 ft. long by about 65 ft. deep front to back, with heavy towers at two corners. It is roofed with slate, the roof being carried by the outside walls and eight columns, in two rows of four, in the inside. The interior of the walls, the altar, sacristy, and the arches are beautifully decorated. The windows are filled with art glass. The whole building weighed approximately 4,500 tons.

The building was first of all loaded on 12 running timbers of 14 in. by 16 in. section, which were placed under the walls, &c., across the structure from front to back. These timbers carried other cross-timbers, also 14 in. by 16 in., and upon the latter were placed groups of two, three or four 8-in. rolled steel joints on which the load of the brickwork was taken direct. The groups of joists were spaced approximately 3 ft. centre to centre.

A general idea of the building will be obtained from Fig. 1, page 842, while Fig. 2 shows the timbering used in the moving operations. The disposition of the timbers, &c., is shown in detail in Figs. 3, 4 and 5, which all show details of one corner with the adjacent arrangements. In Fig. 3 will be noticed one of the 12 running timbers, shown again in Fig. 4, where a pair will be seen under one wall, and a single timber further from the corner. The cross-timbers, of 14 in. by 16 in., are also shown in both these figures, as are also the groups of 8-in. joists.

Fig. 3.

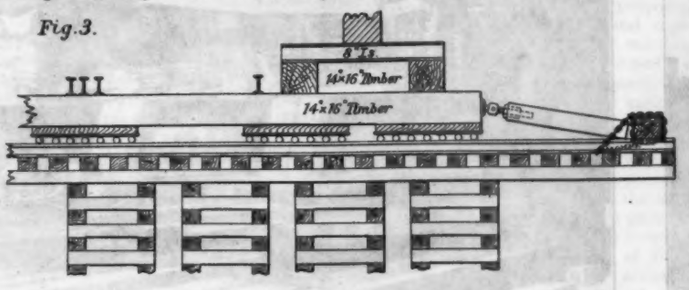


Fig. 5

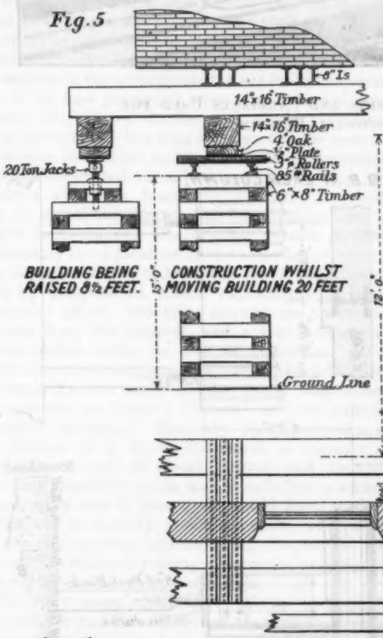
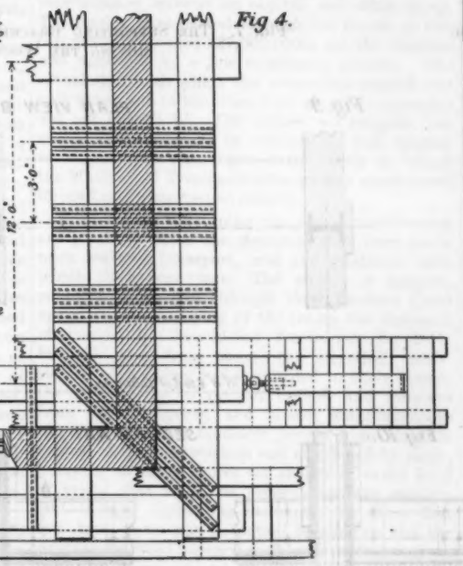


Fig 4.



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The next operation consisted of raising the building a height of 8 ft. 6 in. This was accomplished by means of 800 20-ton screw jacks placed under the running 14-in. by 16-in. timbers, 12 lines of cribbing being built up of 8-in. by 6-in. timbers as the lift proceeded. These are shown in position in our illustrations, while to the left in Fig. 5 is shown one of the lifting jacks in position. The maximum height of the cribbing was 15 ft. When raised high enough 85-lb. steel rails in pairs were laid on the lines of cribbing, under the running timbers, as shown in Fig. 2, 3 and 5. On the top of the rails were placed 3-in. steel rollers, and between these and the timbers were arranged ½-in. steel-bearing plates and 4-in. oak packing pieces. The building was then lowered out and the load taken by the rollers and rails.

The actual move was accomplished by 10 jacks placed against the ends of the running timbers, the foot in each case pressing against a short balk anchored by chains to the rails and cribbing. The position of these jacks is shown in Figs. 3 and 4, and in the view in Fig. 2. They were operated by hand and the 20-ft. move was completed in 18 hours. The building was then taken on vertical jacks again and the level finally checked. New foundation walls were built on the fresh site, and the structure underpinned, after which the timbers, joists and jacks were removed. The whole operation was completed without cracking or other damage to the building. Special care was taken to maintain the building level at all times, to avoid risk of cracking. This was checked throughout the operation by levelling with a view to dealing promptly with any settlement which might occur.

Throughout the work the building continued in use, services were held as usual and lighting, heating and sanitary conveniences were maintained. A temporary entrance shown in Fig. 1 was provided to give access to the building. This illustration, it should be noted shows the building raised and on its new site.

Our remaining illustrations, Figs. 6 to 10, page 844, refer to a steel frame building of eight stories covering a ground space of 20 ft. by 80 ft. The structure has brick wall filling, and fireproof flooring. It weighs about 5,000 tons. It stood at the corner of Second-avenue and Wood-street, Pittsburgh, and had to be moved 40 ft. to the north for the purpose of widening Second-avenue. The move also necessitated raising the whole a matter of 12 in. The building in question was the Joseph Woodwell Company Building. It was occupied by business offices, &c. The whole was supported by 12 large steel columns, the bases of which were carried by reinforced concrete piers over piles. The bases of the six columns on the south side were at basement floor level, while those on the north side were carried down 15 ft. lower, as on this side it had been intended to erect next to the building a 20-storey structure, for which the wall on this side would act as a party wall. These long columns were cut off by means of the acetylene torch at basement floor level, before the building was moved.

The building was lifted, and carried during moving by special brackets riveted to the main columns in the basement. These temporary brackets are illustrated in Figs. 8 and 10, and may be seen in the view reproduced in Fig. 7, though the latter does not show very plainly their attachment to the columns. On either side of each column was riveted one ⅞-in. and one ½-in. plate, measuring 8 ft. 1 in. long across the column, and having a depth of 4 ft. 9 in. at the centre, where a gusset was formed which was riveted to the flanges of the columns. These plates and the edges of the gussets were stiffened with angle irons. Two 6-in. by 4-in. by $\frac{7}{16}$ in. angles ran along the top and bottom, and six 4-in. by 3-in. by ½-in. vertical stiffeners were riveted to the wings, which were intended to take the load. The riveting was ⅞ in.

The floor was laid with 3-in. planking close together, and on the top of this were placed 12-in. by 12-in. timbers at 18 in. centres, as will be seen from Figs. 8 and 10. Across these were laid again additional 12-in. by 12-in. timbers, placed so as to take 24 sets of 20-ton jacks arranged at about 12 in. centres. The arrangement of the jacks in two lines on each side of each column will be seen in the right-hand half of Fig. 8, which shows how the building was first lifted before being moved. Above the jacks were placed ½-in. steel plates, between which was a 3-in. thickness of hardwood. On this packing rested the long girders supporting the wings of the brackets, and serving to distribute the load over the jacks. These girders were about 11 ft. in length, and each consisted of three 24-in. by 100-lb. steel joists with wood filling. When lifted the required amount the packing and rails shown in the left half of Fig. 8, and in Fig. 10, were inserted. Eighty-five pound flat-bottom rails were laid in groups of four, resting on 6-in. by 8-in. wood packing blocks. Between the rails and the ½-in. bearing plate under the packing below the 24-in. joist girders, were inserted a large number of 3-in. steel rollers (Fig. 10), something like 900 being used in all. The building was then ready for moving.

This part of the work was accomplished with twelve 20-ton jacks as indicated in Figs. 9 and 10. The movement was at the rate of 3 ft. per hour, the jacks being worked by hand to the order of a foreman who gave signals with a whistle, when

THE MOVING OF BRICK BUILDINGS.

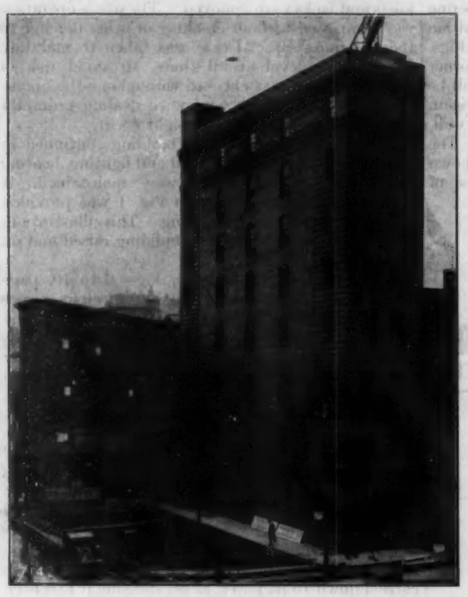


Fig. 6. The Woodwell Building, Pittsburgh, Standing on the New Site.

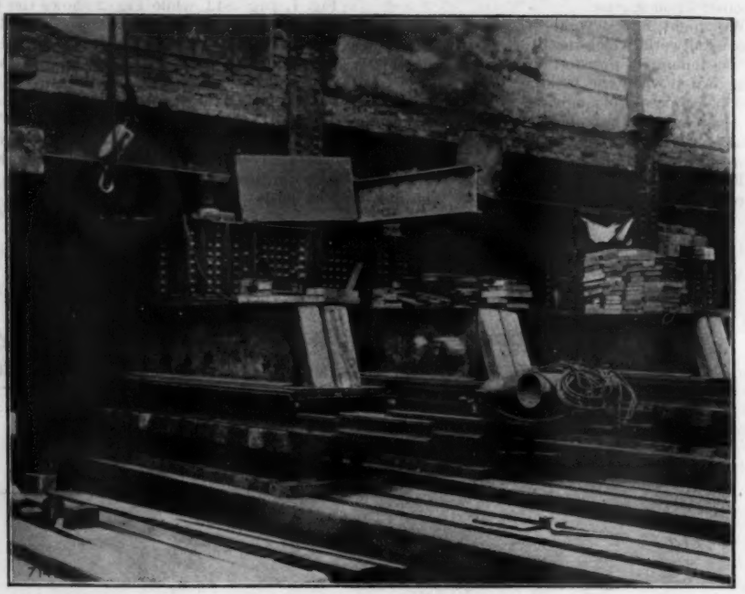
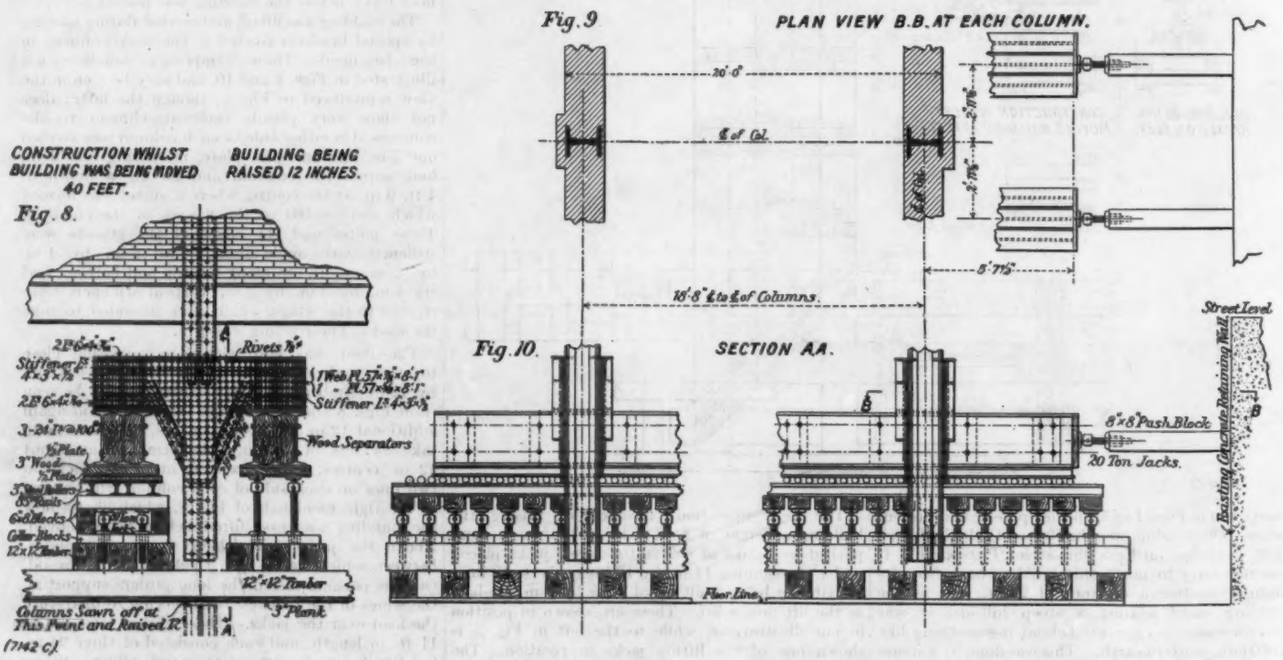


Fig. 7. The Supporting Brackets and Carriages Used for Moving the Woodwell Building.



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all the jacks were given a partial turn together. The strata under part of the area consisted of sand and gravel beds, but the preparations made were so adequate that no settlement occurred at any point. During the work check levels were taken. Previous to moving the building 12 piers of reinforced concrete had been prepared on the new site, to receive the building. The old cast-iron bases of the south side columns were removed to six of these new piers, while to the other six columns which had been cut through, new bases were riveted. The building was finally lowered out on to these, and the wings of the temporary brackets cut off by the acetylene flame.

A conspicuous feature of the work was the fact that the cellar area extended under the sidewalk, and as the pavement was of reinforced concrete, integral with the building, the whole of the pavement which extended round two sides of the building was taken with it to the new site without dismantling. The view in Fig. 6 shows the building on its new site, and the spot from which it has been moved. We are informed that business was carried on as usual in the building during the operations, and even during the actual moving access was not interrupted, neither was there any discontinuance of the elevator, electric lighting, gas, steam heating, telephone or sanitary services and conveniences inside the building. We understand the contract was carried out for a sum between a third and a quarter of the amount it would have cost to rebuild the whole on the new area. About 100,000 ft. of timber, 300 tons of rails and joists and 1,000 jacks were used in the operations. This will give some idea of the amount of preparation necessary for work of this kind to ensure satisfactory results.

German Engineering Enterprise.—A large new undertaking, an offshoot of the Siemens and Halske concern, has been formed in Germany; the Nüremberg Schuckert Company and the Siemens-Schuckert concern in Berlin are also interested in the new venture. It has been started for the purpose of constructing hydro-electric power stations, railways, harbours, ferro-concrete works, &c. Apart from its own capital, the company can, it is stated, avail itself of credits through the interested companies.

LITERATURE.

British Railways and the Great War. Organisation, Efforts, Difficulties and Achievements. By EDWIN A. PRATT. In two volumes. London: Selwyn and Blount, Limited. 1921. [Price 42s. net.]

THE author of this detailed and laborious work is well known from his writings on transport problems, particularly in connection with canals, and is in every way well equipped to tell what the management and staff of the British railways accomplished in the Great War, and what influence their energy and resources exercised on the prosecution and issue of the War itself. Facilities have been provided him for consulting official minutes, correspondence and memoranda; personal interviews have been granted him by authorities in order that he might glean details which have never been put on record. But the work is not to be regarded as an official production, either on the part of the Railway Executive or of the Board of Trade. The author has been allowed to use his own discretion in the selection of material and in his method of using it, taking upon himself full responsibility of any faults of commission or omission. He aims only at producing an historical record, with no intention of serving either the purposes of propaganda or entering upon a discussion of post-war problems. It may be regarded as a tribute to those who worked assiduously for the attainment of worthy ends, animated by the sole purpose of supporting the Government and achieving success.

It is difficult to trace the principle that has guided the author in the arrangement of his bulky material, but if he had preserved some chronological continuity, the interest in the work would have been better sustained. In a long work, such as the present, extending over some 1,200 pages, the preservation of some connected thread is necessary to keep the reader's attention from flagging, and to assist him in perceiving the reasons for adopting lines of action in particular emergencies, as also in comprehending the difficulties that had to be overcome. The separate chapters have too much the appearance of independent tracts, explanatory of some particular phase, but they acquire no additional interest from the context, and a true perspective is impossible owing to lack of coherence. It is perplexing to encounter a chapter on the difficulties of demobilisation early in the book, sandwiched between one on 'Season Tickets' and one later on 'Belgian Refugees.' Similarly the description of the services at S. Paul's Cathedral, in memory of the railway men of Great Britain and Ireland, who had joined the ranks and been killed in action, seems sadly out of place. It would have made a fitting end to a story of self-devotion, whereas in its present position the following chapter on the connection between railway companies and steamship owners comes as an anticlimax.

The story opens effectively. We see the reward of prudence and foresight that through long years of silent preparation had organised the railways and enabled them to co-operate with the national defensive forces, so that when the day of mobilisation came, the carriage of troops and munitions could go forward with smoothness and alacrity. Ever since the Volunteer Movement of 1859 had its origin, plans—feeble and tentative—were set on foot to permit the transport of large bodies of military in time of war. As the network of railways increased, as rolling-stock multiplied, and communications between routes grew more intimate, organisation moved on parallel lines, and every year saw new time-tables adapted for mobilisation, each more complete than the last, and more thorough in its arrangements. The regularity of despatch and the arrival of troops at their destination in the early days of the war testify to the value of peace time preparations, which enabled the railway officials, immediately on the outbreak of hostilities to meet the demands made upon them by the military authorities. The railway system is a complicated piece of mechanism, that would, if imperfectly organised, inevitably break down under the strain of abnormal demands, and possibly precipitate the army and the country into a mass of confusion worse than if the railways had never existed.

When it is remembered that the Government took over no less than 130 separately-owned railways and worked these as a unified system, it will be better understood what had been the work of the Railway Executive Committee, the body to whom the task of organisation had been entrusted. The principle of establishing physical connections between the various railway systems had been carried to such an extent, that at the outbreak of war, the construction of only four new junctions was recommended by the War Office, but even without these, the perfected system permitted the rolling-stock on all lines to pass without break from Penzance to Thurso. Although the railway routes had never been designed for strategic purposes, yet the various lines, branches, links and communications had been so planned and were so complete in themselves, that though schemed by commercial companies to meet the demands of their own transport, yet they served the military purpose as effectively as if they had been specially designed. It is illuminating to contrast the small staff of the Railway Executive Committee with the numerous personnel which seemed indispensable to some other State Departments. At the outbreak of hostilities the staff consisted of six persons, but soon after it was found necessary to increase this number to eight, and by the spring of 1917, the staff numbered no less than 17. An accountant's committee undertook the important and responsible duty of distributing among the controlled railway companies the sums due to them on account of work on munitions, for the monthly and annual claims for compensation, arrears of maintenance, interest on capital, and other items. The money that passed through the hands of this committee exceeded 227,000,000*l.*, yet the business was managed by a few competent persons. The actual staff with which this committee started was only three, and at the time of its greatest expansion did not exceed 12. The author, we imagine, has not a little pleasure in contrasting this modest assistance with the "grandiose" scale in which the Ministry of Transport subsequently constructed its staff and apportioned salaries.

Many details concerning the plan of mobilisation are given to show the demands that were made upon railway transport, and the readiness with which they were met. The picture is graphic, enabling us to live through those anxious times again, see the hurrying of the trains, the despatch of troops, the bewildered Territorials hurriedly brought back from camp, the stranded excursionists clamouring to be returned to their homes, the precautions to protect bridges and railways from alien suspects, and almost simultaneously the arrival of the homeless people from Belgium robbed of their possessions and maddened by panic, hurrying to these shores for shelter in every kind of vessel that could be pressed into the service. But though much was attempted in those first few days, there was no actual breakdown and the programme went forward with such perfect success, that the trains arrived at Southampton generally in advance of their schedule time. In eight days from August 10–17, 334 trains carried to Southampton 69,000 men, 21,000 horses, 166 guns, with some thousands of tons of baggage, bicycles and other vehicles. It all seems very far away now, but the author's picture is worth studying, if it makes us appreciate more exactly the effect that rail power, organised and operated with efficiency, has in determining the course of war. It was rail power that enabled the Battle of Mons to be fought a fortnight after the embarkation at Southampton had begun.

It is this lesson of the value of railways and of transport that Mr. Pratt seeks to bring home, by showing the part the railway service has played in very varied capacities, and in every emergency that has arisen. Is there a shortage of wagons for the Army? The companies have to trace the cause and show the extent of the misusage that is rampant, and supply the deficiency. Are ambulance trains needed for the Army or the Navy? The Railway Executive are asked to adapt exisitng rolling-stock to the pressing need. Is mobility impaired by want of locomotives? The companies have to supply them, though their store may be so depleted that the home service is prosecuted with difficulty. Rails have to follow the same road as the rolling-stock, and finally when the railway yards are stripped of their equipment, comes the request for 200,000 sleepers to be taken from the supplies in hand, the need for new lines on the Western front being so urgent that the delay in obtaining sleepers from other sources may prove fatal. And not only is this drain on material continuous and incessant, but the companies suffer from the loss of many of their most competent servants. With demands for rapid delivery of manufactures stores fron the Ministry of Munitions, with increased passenger traffic owing to the desire of many to escape from the Metropolis on account of the alarm created by air raids, with the transport of prisoners of war and of men on leave, with carriage of goods on an unprecedented scale, especially of coal and oil for the Admiralty, the staff of competent and trained servants was materially reduced. The companies' employees contributed 184,000 men to the defensive services of the realm, while 2,000 officers of high training and profound skill in management, were withdrawn to render temporary services to the Government. The author finds it easier to tell us that the work was done, that every demand was met, than to say how it was done with the men and material at command. But the truth is that men and women worked in those days as they have not worked since, and the enormous amount of energy latent in the nation was disclosed and drawn upon.

Have the services rendered been adequately compensated is a question that is debated at some length. The original agreement with the Government on assuming control over the railways under the Act of 1871, arranged that the compensation to be paid should be the sum by which the aggregate net receipts of the railways for the period during which the Government were in possession fell short of the aggregate net receipt for the corresponding period of 1913. There were subsequent revisions of the general terms, mainly on account of the increase of wages, arrangements being effected by which 25 per cent. of the war bonus granted to railway employees who came within the Railways Conciliation Scheme, should be borne by the railway companies and not by the Government. Subsequently, as it was admitted that the new works erected by the companies were earning revenue of which the Government reaped the benefit, while the respective companies had to meet the interest accruing on the new capital, it was agreed that a further sum of 4 per cent. should be paid on all moneys, expended on works, rolling-stock, plant and land during the time such works were under control. Further the Government were to make a cash payment to each of the controlled companies, equal to the difference between the book value of the stores in stock on August 5, 1914, and the value of the same quantities of similar stores at the end of the period of control. Apparently these are the only pecuniary obligations on which the Government entered with the companies, and it is generally considered that the Board of Trade made a very good bargain on behalf of the country. But Mr. Pratt does not help us to form a distinct estimate of the amount. When the service was "nominally free," and such service was not paid for at the time it was rendered, it was assumed that the unpaid service would increase, to a corresponding extent, the deficit in the railway companies' revenue, determined by comparison with that of the standard year of 1913, which was to be made good by agreement. It is evident therefore that if in any one year the net receipts of the controlled companies were equal to those of 1913, the whole of the Government traffic would be carried absolutely free. A necessary corollary is, that however great the traffic might become, the profit could never exceed that of the normal year of 1913. In estimating the pecuniary value of the company's services to the nation, therefore, it is necessary to compare the amount of the compensation due for any one year under the guarantee, with the sum total of the charges the Government would have had to meet if they had paid cash. Apparently the data exist for framing an estimate of the difference, but the author does not quote any figures, and we are forced to imitate a similar discretion.

A very interesting chapter is that bearing on the

relations between railway and coasting services. The author made himself so familiar with transport questions that his handling of this problem is very illuminating, and we regret that want of space prevents us from giving a satisfactory summary. The war effected a reversal in the circumstances under which an active competition had been carried on between the two methods of transport, since the advent of the railway era. When the coastwise shipping interests flourish, the railways complain of loss of trade, and when the railways secure increased traffic, the coasting shippers ventilate their grievances. Efforts at compromise have led to the establishment, and withdrawal, of so-called "emergency rates." A permissible "Refusal of Traffic" agreement became for a while a burning question. A method of subsidies, based on a kind of sliding scale, was tried, and only recently abandoned by the Ministry of Transport. The interests of railways and of the coasting trade are apparently incompatible, and are certainly not accommodated yet. The author is a safe guide through all these intricacies of transport economy, and we regret that the demands upon our space prevent us from following him in his discussion of the vexed question of pooling all privately-owned wagons on railways, or of that broad scheme of amalgamating railway companies into groups, inaugurated by the Ministry of Transport with the view of avoiding uneconomical competition.

Rays of Positive Electricity and their Application to Chemical Analysis. By Sir. J. J. Thomson, G.M., F.R.S., Master of Trinity College, Cambridge, Professor of Experimental Physics, Cambridge. Second edition. London: Longmans, Green and Co., 1921. [Price 16*s.* net.]

In the concluding chapter of his well-known textbook on Heat, Clerk Maxwell observed that the atoms were "unalterable by any of the processes which go on in the present state of things" and that they were "the only material things which still remain in the precise condition in which they first began to exist." The edition from which we have abstracted the foregoing was published in 1880, but the views there expressed did not long remain unchallenged. In his "Naturalism and Agnosticism," James Ward criticised the claim on philosophical grounds, whilst on the Continent, and particularly in Germany, there grew up a school which denied that the atom had any objective reality; being merely a convenient fiction, the utility of which was being rapidly discounted by the progress of abstract thermodynamics.

This creed is now known to be untenable in view more particularly of the phenomena associated with radioactivity, so that in this regard Maxwell's belief has been substantiated, but his contention that the atoms were unalterable by any of the processes which go on in Nature, broke down when, in 1897, the author of the work we are reviewing showed that it was possible "to knock chunks off them," in the shape of electrons. The atoms accordingly had a structure, and during the past twenty-five years many physicists have laboured to lay this bare. As Henri Poincaré once observed, the chink, through which information can reach us as to the internal structure of the atom is a very narrow one, and to gain access to the actual interior, extremely powerful agents, such as are afforded by the α particles and by the γ radiation have to be employed. These have shown that the core of the atom is extraordinarily minute and is charged with positive electricity which is surrounded by shells of electrons, and it is the outermost of these shells which is responsible for such atomic properties as constitute the subject-matter of chemistry. The chemist, however, can tell us merely the characteristics of a mob. Even if he uses the spectroscope, he requires so large a number of atoms to work on that had we no better test for the existence of humanity we would only just be beginning to suspect that the earth was inhabited. By electrifying an atom, however, the work of detection is so facilitated that even a single atom may manifest its existence, as is well exemplified by Crookes' spirothariscope, where the impact of each individual α particle is registered on the phosphorescent screen. These α particles are, of course, spontaneously electrified, and what is still more important spontaneously accelerated, the speeds obtained by them being far in excess of what it has up till now proved practicable to attain by artificial means. The electrified atoms and molecules, which constitute the canal strahlen discovered by Goldstein in 1886, have much more moderate velocities, being of the order of 500 miles per second, in place of the 20,000 or so with which the α particles move, but nevertheless the investigator who studies the behaviour of atoms and molecules by the positive-ray methods developed by Sir. J. J. Thomson, can deal satisfactorily with quantities of matter which may be regarded as infinitesimal relatively to the smallest masses the chemist can successfully handle. From time to time, Professor Thomson has described the progress of these researches in lectures delivered at the Royal Institution, and these have been pretty fully reported in our columns. As was fitting both to the occasion and the audience, in delivering these lectures the Master of Trinity employed his remarkable powers of clear exposition rather to explain the nature of the mechanism at work and the conclusions attained, than to a discussion of the mathematics involved, or to a minute description of the experimental details. The omission is made good in the present volume, where the precautions essential to success are minutely described, and the elementary theory of the apparatus adequately developed.

Goldstein discovered that if in a discharge tube the cathode were perforated there streamed through the opening a peculiar system of red rays which were capable of causing certain substance to fluoresce, if placed in the path of the rays. Subsequently Wien showed that these rays were deflected when they passed through a strong magnetic or electric field. The theory of such deflections shows that, when such fields are simultaneously applied to a fine pencil of these canal strahlen or positive rays of the same kind, but moving with different velocities, the locus of the points of impact will be a parabola, and that by measuring the displacement from the point struck by the undeflected rays the mass of the particle producing any particular parabola could be calculated.

The physical verification of this deduction, however, met with extraordinary experimental difficulties. At the outset it was hardly possible to demonstrate more than that the positive rays consisted of positively-charged particles of approximately atomic dimensions, whilst as now developed, positive-ray analysis appears to provide the simplest method of determining atomic weights. Where chemical methods are used not merely must a relatively large mass of material be available, but this must be purified with extreme care. With the positive-ray method a mere trace of the element suffices, and no particular pains need be expended in purifying the sample to be tested, whilst the accuracy already attained approaches that of the best chemical determinations, and will almost certainly be ultimately found to surpass this standard.

The early difficulties arose from the fact that if the pressure in the discharge tube was reduced beyond a certain limit no current passed and no positive rays were obtained, whilst if the pressure were high enough to secure the satisfactory working of the discharge tube, the positive rays in their path from the hole in the cathode to the phosphorescent screen, came into collision with so many molecules that they were scattered in all directions and the screen showed accordingly mere blobs of luminosity instead of a sharply-defined and measurable trace. The difficulty was overcome by dividing the tube into two compartments communicating only by a very long and fine hole through the cathode. The portion in front of the cathode constituted the discharge tube, and in this the pressure is maintained at the value found to give the best results, whilst in the chamber behind the cathode which the positive rays traverse on their way to the screen a much lower pressure was maintained by connecting it to tubes filled with charcoal and immersed in liquid air. The channel through the cathode consists of a copper tube about $2\frac{1}{2}$ inches long and $\frac{1}{10}$ mm. or less in diameter, and through this the rate of diffusion is so slow that there is no difficulty in maintaining a considerable difference of pressure between the two compartments. Full details are given in Professor Thomson's book. The pencil of positive rays comes through the fine tube, and this must accordingly be quite straight. The target now used is a photographic plate, by means of which permanent records are obtained which can be measured up at leisure. The time of exposure varies from $1\frac{1}{2}$ hours to 2 hours. For adjusting the apparatus preparatory to taking a photograph a screen covered with Willemite is used, which phosphoresces under the impact.

One of the most striking of the earlier observations made was that neon was a mixture of two isotopes, the existence of isotopes though inferred from radioactive phenomena, had not at that time been satisfactorily demonstrated.

Sir J. J. Thomson gives a very interesting discussion of the origin of the charged ions which constitute the positive rays. He concludes that for the most part they do not arise from molecular collisions, but are secondary effects, and are due to radiation. This is in accord with views as to the cause of chemical dissociation which the author put forward in a paper published in the *Philosophical Magazine* so far back as 1884. In this paper he pointed out that if the dissociation of iodine were directly due to molecular collisions the rate of dissociation should increase as the square of the number of undissociated molecules present, whereas experiment proved that the rate varied as the number present and not as the square of that number. He suggested accordingly that the effective agent was radiation. This view has recently been revived by Professor Perrin, and fits in remarkably well with many firmly-established facts of observation, though, we believe, there are still some outstanding difficulties.

In a later section of his work, Professor Thomson develops further those far-reaching views as to the meaning of valency and the nature of chemical action which have led to the exceedingly interesting and suggestive speculations of Longmuir and others. He points out that chemical compounds can be divided into two distinct classes. In one class the constituent atoms are individually neutral, whilst in the other class the act of combination involves the passage of an electron from one atom to its yoke-fellow. The resultant compound is neutral, but the distance between the positive and negative charges which neutralise each other is far greater than it is in a neutral atom. The stray field which is responsible for the residual valency is accordingly far stronger, and the molecules associate readily with each other to form compound molecules. Moreover, such bodies have an abnormal specific inductive capacity, and ionise salts dissolved in them.

The speed of the positive rays being of the order of 500 miles per second and the distance between cathode and target being less than a foot, any particular particle is under observation for only an almost infinitesimal time. It is not surprising, therefore, that the presence of compounds has been detected, which are so unstable that they have never yet been observed outside of the tube. Shortly after the discovery of argon, Bertholet professed to have succeeded in making it enter into chemical combination, but his observations were not confirmed, and so far as present evidence goes the inert gases as we know them in the mass are incapable of taking part in chemical combinations, although the fact that they can be liquefied seems to indicate that they are not entirely devoid of residual affinities. This is confirmed by the positive-ray analysis, where evidence has been found not only of double molecules of helium, but of a combination of helium with hydrogen. Another curious aggregate found is the molecule H_3, that of ordinary hydrogen being represented by H_2, and it would appear that even higher complexes of H are met with.

The volume under notice concludes with a highly suggestive discussion of the mechanism involved in the formation of chemical compounds.

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Compteurs de Vapeur. Par E. HŒHN. Paris: Ch. Beranger. [Price 12 francs.]

RUST PREVENTION BY OIL FILMS.—Oil films prevent the rusting of iron, but they are not impervious to water vapour. Hence mere oiling cannot prevent the corrosion of rifle barrels, on the inside of which the discharges of the explosives have deposited potassium chloride, which absorbs atmospheric moisture; liquid water then comes in contact with the iron. Other bad influence from traces of salts were also observed by W. J. Huff, of the United States Bureau of Mines, when inquiring into the problem. It was suspected that oiled polished steel wares packed by certain men were more apt to rust than others, and the rusting seemed to be connected with the finger prints of these men (*Chemical and Metallurgical Engineering,* November 9). Rifle barrels should carefully be washed and dried by wiping, after having been discharged, and then be oiled. The washing and still more the drying are, however, difficult in some inaccessible parts of barrels and other mechanisms. Huff therefore tried whether certain emulsions would take up the water and thus inhibit corrosion. He found that an emulsion of ammonium oleate in water containing 2 per cent. of the oleate or a mixture of this emulsion with transformer oil would not corrode; he recommends washing, rinsing with this emulsion and oiling.

DESIGN AND CONSTRUCTION OF U.S. PASSENGER STEAMERS.*

By Mr. E. H. RIGG, Member of Council.

(*Concluded from page* 839.)

The Beginnings of our Post War Passenger Fleet.—During the war our dependence on allied transports for the army troop movements was only mitigated by our few pre-war troopers and liners and by enemy tonnage seized in our harbours and elsewhere. This led to the ordering of some 20 odd large, and some 30 odd moderate sized transports at Newport News, Bethlehem, New York Shipbuilding Corporation and Hog Island. None of these vessels was completed prior to the armistice, and some were subsequently cancelled, mainly the smaller ones at Hog Island. These ships are now in service, some as troopers (Hog Island) and some as passenger liners, with the latter of which only are we here concerned.

A brief description of these passenger ships is in order and may well be given in tabular form. Of the larger ships, Newport News built 2, Bethlehem 5, and New York Shipbuilding Corporation 9, a total of 16 ships of some 225,600 gross tons; the smaller ships number 7, all built by the New York Shipbuilding Corporation, totalling some 73,800 tons gross.

Their outline particulars are as follows:—

Item.	Old North State Class. (Figs. 1 to 14.)	American Legion Class. (Figs. 15 to 27.)
	ft. in.	ft. in.
Length overall	522 8	535 2
Beam, moulded	62 0	72 0
Depth, moulded	42 0	50 0
Load draught	32 3	30 7
Corresponding deadweight	13,000	11,400
Sea speed, knots	14	17½
Shaft horse-power	—	12,000
Indicated horse-power	6,500	—
Boilers (oil fuel)	Scotch	Water tube.
Motive power	Reciprocating engines	Geared turbines
First-class passengers	78	260
*Third-class passengers	—	300
Gross tonnage	10,540	14,100
Crew	117	134
Bulkheads	11	13

*Two of the smaller ships are being fitted for third-class passengers in the top 'tween decks.

A few words on the outstanding characteristics of these ships may be in order:—

1. *Passenger Accommodation.*—This is usually spacious, as may be inferred from the size of the ship and the number carried. Large rooms, beds rather than bunks, numerous private bathrooms, and ample public rooms are noticeable, especially in the larger vessels. Running hot and cold water is supplied in the rooms.

2. *Cargo Handling.*—Both in the number of hatches and in the facilities at each hatch, this feature is especially well cared for, quick turn around being thus possible.

3. *Unusually Close Subdivision.*—Being laid down as three-compartment ships for troop service in the war zone, these vessels are all very well bulkheaded, especially the larger ones, where cargo is not so important.

4. The interior decoration has received greater care than usual, our colonial period supplying the dominating scheme of architectural effect. This has been modified in certain spaces, such as the verandas, tea rooms and smoking rooms. Furniture, decorations and draperies were from designs by W. and J. Sloane, of New York. The architectural plans for the larger ships were mainly by the Bethlehem Shipbuilding Corporation and for the smaller ships entirely by the New York Shipbuilding Corporation.

5. Unusually large steaming radius to enable Pacific Ocean and South American trades to be adequately negotiated.

6. The similarity of bow and stern is unpleasantly noticeable, this being an inheritance from war days.

Since the launching of these vessels there has been a considerable general interest displayed in passenger ships; numerous designs for large vessels have been prepared which, doubtless, will bear fruit in due season. As business gets back to normal it will carry with it a demand for vessels of this character to balance our merchant marine.

The appearance of a vessel of the "Old North State" type is well shown in Fig. 1 on this page, while the elevation and deck plans are reproduced in Figs. 2 to 11 on page 848, and in Figs. 12 to 14 on page 849. A photograph of a vessel of the American "Legion" class is reproduced in Fig. 15 on page 850, and the elevations and deck plans are given in Figs. 16 to 27 on Plate XLV., which accompanies this issue.

Interior Decoration.—No paper of this character can be complete without reference to such an important feature of passenger ships. The first requisite from the point of view of the passenger, after that of the general good or bad repute in which the line and ship he sails on is held, is that the general arrangement of the accommodation shall be such as to contribute to his comfort—enough promenade space and open decks for games, ample ventilation at all times and heat in winter, well-arranged staterooms and public rooms, access to all parts under cover. An essential factor in all this is the interior decoration. We have had very few papers on this subject, but one in 1915 by Mr. H. B. Etter stands out as a valuable and interesting contribution to the transactions; a careful reading of this paper will repay anyone interested in the subject.

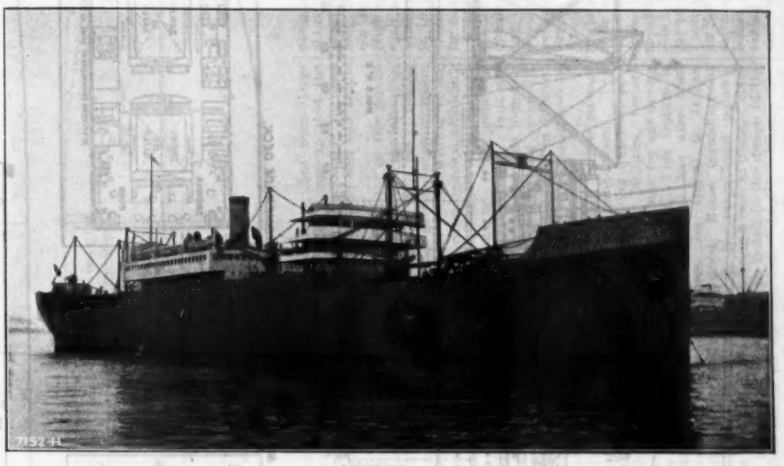


FIG. 1. SHIP OF THE OLD NORTH STATE CLASS.

The architectural or decorative atrocities of a hotel can frequently be recovered from by seeing nearby grand and varied scenery, or by absence for short periods. Not so with a ship: once you start, the scenery is, generally speaking, the sea and then more sea. Also, you are there to the end of the voyage, and if it is a three or four-week voyage, third-rate efforts at decoration can try men's souls.

As in Pullman cars, so in ships, we have happily got far away from the days of heavily applied ornamentation, just as in our houses we demand decoration and furniture which combine grace and usefulness. So in ships it has been realised more and more that good interior architecture and decoration do not necessarily involve additional expense, or rather expense beyond an immediately appreciable return in the enhanced reputation of the vessel in question in attracting passengers. Compare the beauty and general attractiveness of the United Fruit Company's steamers with the vast majority of pre-war coastwise passenger vessels. The United Fruit Company has not lost trade by the quality of its ship's arrangement and decoration; it is by no means a weak and struggling line, made so by wasting its substance on expensive interiors. Visit or travel on one of its steamers and then do the same on any of several coastwise liners; the wood and paint are there, but the decorative effects that could have been obtained from the same wood and paint are not.

Of the later periods which lend themselves to ship decorative architecture the Tudor and Flemish are found most frequently in smoking rooms; the periods of Louis XIV, XV and XVI of France in the music rooms, lounges and galleries. Read the published descriptions and visit modern liners; it is hard to realise the variety of styles which can be adapted to ship decorations. From classic and Gothic in lesser amounts we pass on to a wealth of the Renaissance of Italy and of France, to the English and Dutch evolutions and, lastly, to our own Colonial, the keynote to the decoration of our post-war ships of the American "Legion" class.

We have heard lately of ships that were overdone

* Paper read at the twenty-ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 17 and 18, 1921.

UNITED STATES PASSENGER STEAMER OF THE OLD NORTH STATE CLASS.

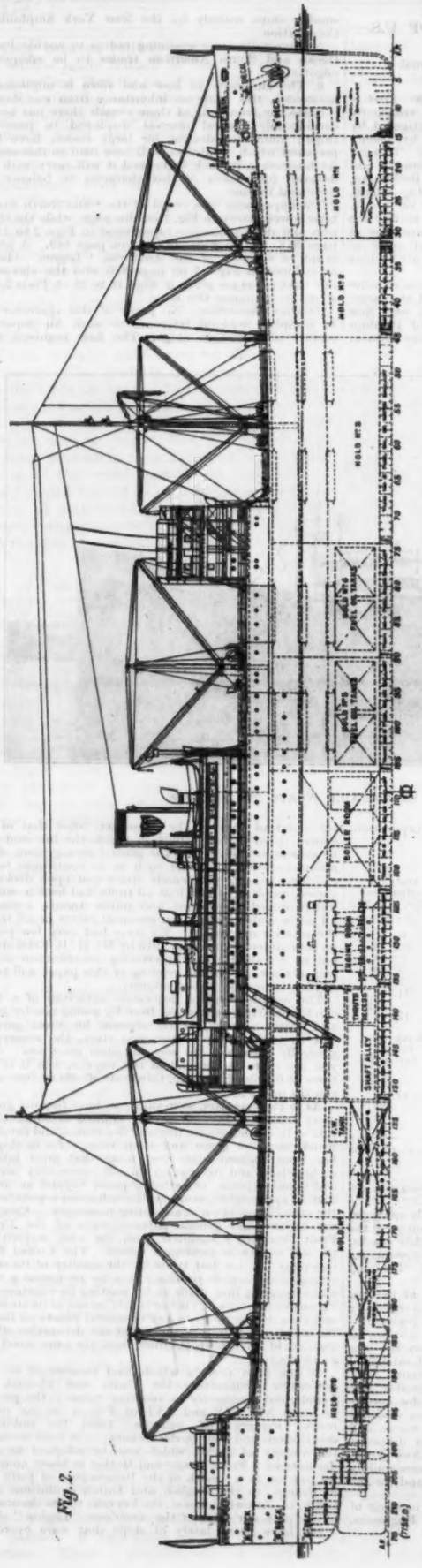


Fig. 2.

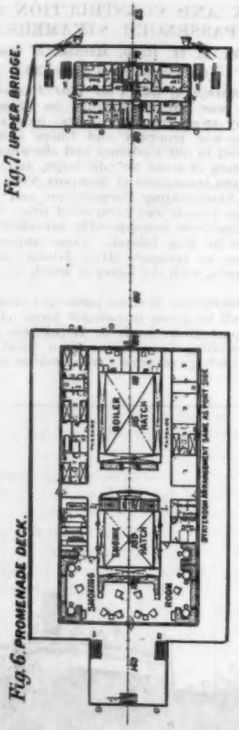


Fig. 7. UPPER BRIDGE.

Fig. 6. PROMENADE DECK.

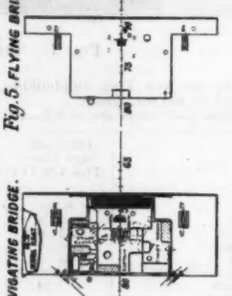


Fig. 5. FLYING BRIDGE.

Fig. 4. NAVIGATING BRIDGE.

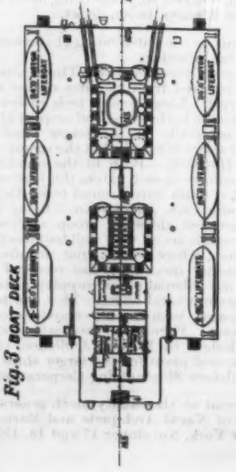


Fig. 3. BOAT DECK

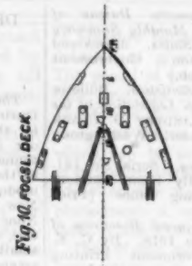


Fig. 10. FOCSL. DECK

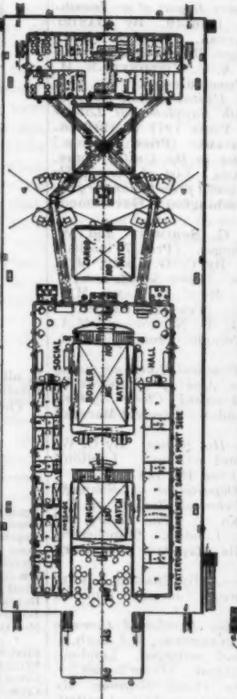


Fig. 9. BRIDGE DECK.

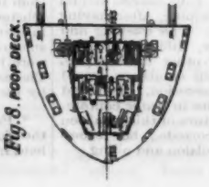


Fig. 8. POOP DECK.

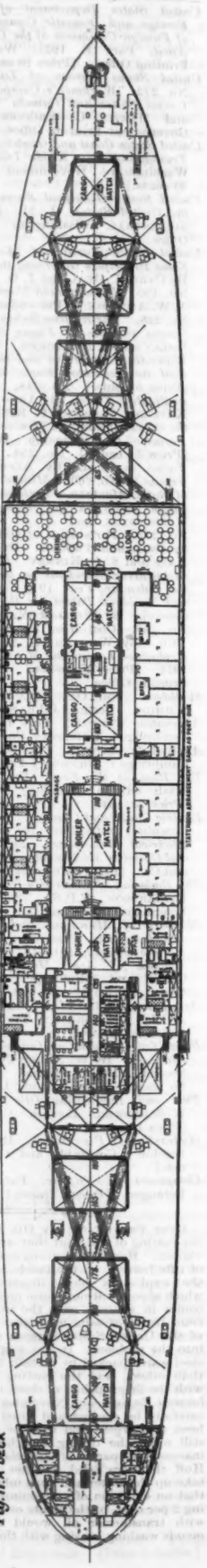
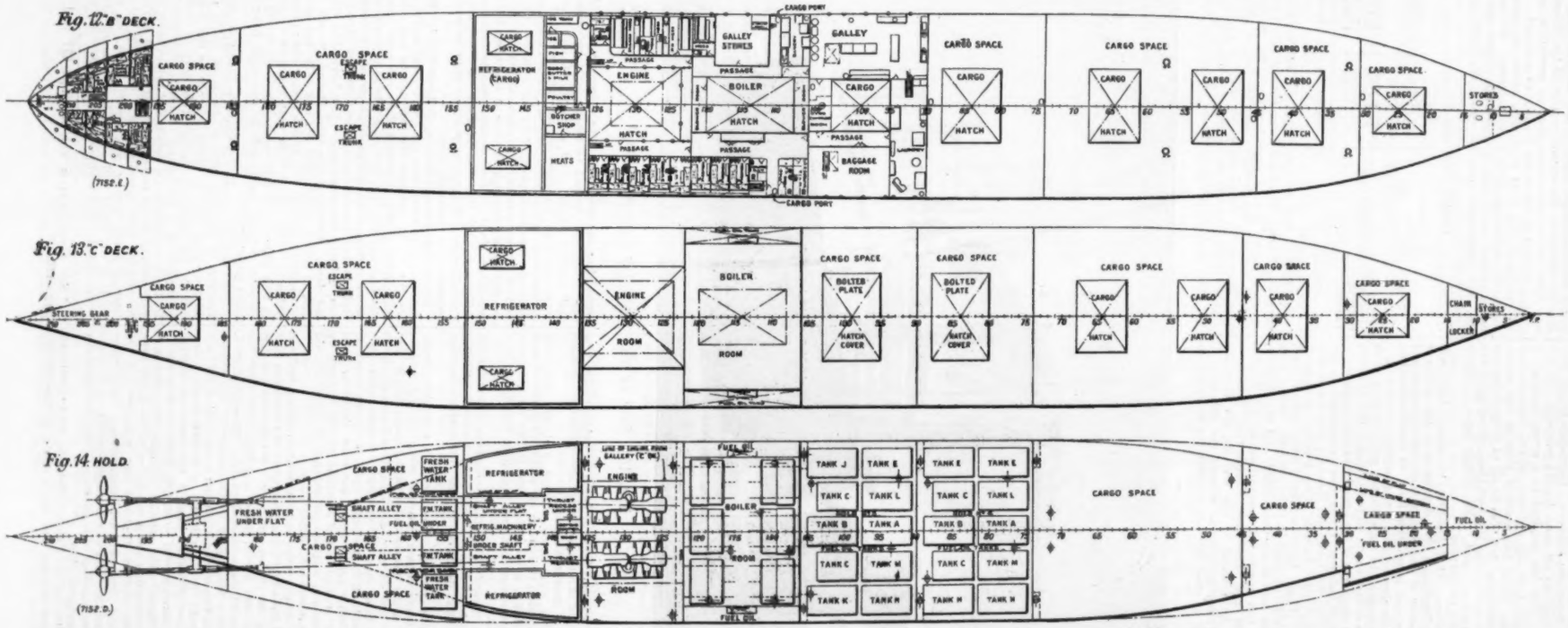


Fig. 11. "A" DECK

UNITED STATES PASSENGER STEAMER OF THE OLD NORTH STATE CLASS.



in the lavishness of their appointments; perhaps so. A ship designed and built for a one-week trip does not need as much in the way of accessories as one that is to be a floating home for four or five weeks at a stretch. Let ships be designed each for their own trade, with due consideration to climates passed through, to the likes and dislikes of the people carried, and to the length of voyage. A rational answer to these questions will settle both the decorative and elaborateness questions.

The impression may have been given that copying the past is the only way to decorate a ship; this is not intended. Certain it is that the past, so far as it has been spared by the hand of the ignorant savagery that breaks out in humanity at intervals, furnishes us with a wealth of background to work on. The masters of all the ages have left work for us to admire and beat if we can. From Persia, Egypt, Greece, Rome, Italy, France and Europe generally do we inherit. The classic styles of Greece and Rome lead on to the Gothic and the later periods of Italian and French Renaissance, the Tudor, the Dutch, the periods of the Louis, the Regency, Empire, Adam and Colonial; then, too, China and Japan have contributed their share. With the masterpieces of all the ages to draw from, we would be poor indeed if, while working out new ideas and adaptations, we fail to give credit to the sources of inspiration.

The latest word in large liner decoration that the public has had a chance to see is that of the Paris* of the French Line; a visit to this ship leaves no doubt as to the artistic ability of the French designers and decorators. She is very much of the dimensions of the Mauretania. Large 'tween-deck heights prevail; in the upper public rooms extra height has been obtained by extending the central part up several feet. With the general scheme of decoration it is hard to find fault, though our friends of the plain and simple school had better travel on some other ship; the ornamentation is in excellent taste, the result being magnificence without gaudiness. The large windows in the public rooms give one the impression of a palace rather than a ship; they are protected by the outer windows enclosing the promenade.

Extent of Arrangement in Public Rooms.—The arrangement which is popular in sheltered water ships of wide passages and seats, writing tables, &c., running along inside the staterooms, often with large wells at intervals, is not adapted to sea-going liners. The arrangement which works out best in ocean-going ships gives dining rooms on the lowest passenger deck with galleys and pantries around the casings and extending full width, the other public rooms being arranged on the top deck, opening one from the other and with wide passages or galleries between, enabling the best all-round result to be obtained. The dining rooms thus occupy decks the least desirable for state rooms, the other public rooms can be built with coach-top effect, enabling rooms of 10 ft. and 11 ft. head room to be obtained; decorative effects impossible of attainment in the ordinary 'tween deck at once become possible, comfort is increased and the ship popularised. A dome over the dining saloon with exhaust fans is a most important contribution to comfort, coolness, lighting and decoration. Some large pre-war liners have winter gardens two full decks in height, a most magnificent arrangement but also a most extravagant one.

Many have arrangements for dancing indoors as well as on deck; promenade decks with fully enclosed sides give excellent facilities for dancing, but some large liners go further and arrange the lounge so that the central part can be cleared and a ball room of the best obtained, with orchestra gallery at one end and ample seating on all sides.

Some idea of the extensive character of the public rooms of a large liner may be obtained from the following, without by any means exhausting the list: Dining rooms, restaurant or café, winter garden, smoking room, card room, library, lounge, ball room, writing room, entrances and lobbies, stairways, drawing room, children's dining room, nursery gymnasium, Turkish bath, barber's shop, information bureau, ticket, &c., office, galleries, verandas, swimming pool, candy, &c., store. It is not to be understood that all these rooms can be found in any one ship; they are merged and grouped variously. Different names are given to the same space in different lines. The list typifies, however, the extensiveness of the public spaces on a large liner.

In the larger steamers the old-time narrow passage gives place to the gallery between public rooms. This feature enlarges the scope of the living quarters, provides library, reading and writing facilities, besides giving ample communication under cover for use during the evening or during bad weather. This feature is noticeable in recent Cunarders and has also been developed in Italian liners. Its appeal to Italian designers is easily understood, Rome furnishing us with many such galleries in her magnificent palaces, the galleries of the Vatican being a case in point. Some of the gallery effect is to be noted in the design of the public spaces on the American "Legion" class.

Promenades.—Many ships sacrifice this feature to crowding in the maximum possible number of state rooms, obviously to increase revenue. It is true that short run ships do not need so much promenade space and deck room for exercise and games that vessels going on long voyages require. Vessels on one-night runs do not need the open-air spaces that day-run ships need. High-speed ships require more sheltering arrangements, such as deflecting wind shields and sides enclosed with windows which can be either shut or open. The liner, to be popular, must have good open decks for lounge chairs, for walking and for games, with decks adapted for outdoor sleeping on tropical runs.

Outside Rooms.—In smaller ships, all rooms can and should be outside rooms, *i.e.*, with ports or windows opening direct to the outside air. As ships get bigger our difficulties increase; the "Bibby" room is the popular solution, the inside room having a narrow passage leading past the outside room to a port. For vessels navigating sheltered waters the transverse berth greatly helps the designer of good passenger accommodation, but for seagoing ships, the fore and aft berth with only occasional exceptions, is the rule. Lately the "Bibby" idea has been extended to banks of three rooms on a side, both the inner and middle rooms having these narrow passages for air extending directly to the side; for hot weather ships this is excellent. As we get to the largest ships this feature is not so important. These ships are generally fast and, being almost entirely on North Atlantic runs, the heat is not excessive. With eight or more rooms abreast it becomes a problem of better and still better ventilation by means of fans taking air from above. On this route we have fog and ice to contend with and consequently closed ports at night on all decks below the bulkhead line. More and more deck-houses are resorted to, with consequently

*See pages 96, 181 and 246 *ante*.

narrower houses, fewer rooms abreast and more chance for windows directly opening out on deck. The old plan of individual outside doors has given place to inside passages and doors, with outside windows, a cooler arrangement anyhow, avoiding the backing up of rooms against heated casings and enabling all available space, along the centre line to be utilised for toilets and baths, the best scheme for drainage and water supply, also for exhausting foul air directly from these spaces.

Single-Berth Rooms.—No doubt this is a feature appealing to all people travelling alone; the comforts of a little place all your own for the voyage need no eulogies. On the North Atlantic such rooms are now numerous; elsewhere they are not unknown. A most ingenious plan that can be used in all vessels, particularly in those with ample 'tween-deck height, is that of placing two berths over each other, but so stepping the dividing bulkhead that one berth is in one room and the other in another room; in one room there is a lower berth only and in the other an upper berth only. I do not recall which line gets the credit for the scheme, but it is a good one.

Details of Construction.—Standard transverse framing continues to be the general rule for passenger ships. Wide-spaced framing is often adopted in order to get a spacing that suits details of accommodation better. If pushed to extremes, framing too deep for good hold capacities may result, besides very heavy shell plating: in way of machinery, deep framing does not affect capacity; carefully applied, it can be made an advantage.

Longitudinal framing has not the same strong hold as in oil tankers and in long shallow vessels of all classes; vessels for rivers, &c., will always do well to consider longitudinal framing, but for deep-sea passenger vessels, with many decks, its advantages are not so clear.

Cruiser sterns for twin and multiple screw ships are here and do not need so much arguing for as a decade ago; there are still people who do not like their looks and, of course, that is their privilege. They have solid merit, however, in improving stability and speed performances. For single-screw ships they are generally out of place.

Electric arc welding has found a definite place in shipyards; without getting too enthusiastic and hailing the all-welded ship and the exit of the riveter, driller and caulker, it remains a fact that there is ample room for a welding department in any big yard to work on details, and that not altogether, by any means, on what we may politely term "correctional" work.

Wooden decks inside quarters are well nigh a thing of the past in ocean ships; there are several satisfactory plastic deck coverings for all interior spaces other than those generally cemented and tiled. There are also several forms of cork flooring which give good results. Parquet may be desirable for inside dancing spaces. Wooden decks are still premier for open deck spaces over quarters and for promenades.

In order to shorten turn around in port, either ship or dock, and sometimes both, have to be better equipped with cargo gear than was, only a short time ago, considered proper. The Old North State and American Legion classes fully bear this out, their twin derrick systems and numerous hatches having been commented on in every port visited. It should be noted that their close subdivision accentuates this feature.

The recent revisions of the rules of all the classification societies have placed in the hands of the shipyards methods of designing structure and details which enable much quicker and better work to be done.

Joinery work is not so dependent on wood for panels as formerly; as with sanitary floors, so with panelling, there are now on the market several satisfactory composition boards, and panels of these, mounted directly on the tongue and groove partitions, enable the two sides of a bulkhead to be fashioned to suit the furniture to much better advantage than with ordinary panels.

Lighting, heating and ventilation have improved of late; steam heat is largely replaced by electric radiators, which are particularly adapted for individual room heating in association with a thermo-tank system raising all the air to about 60 deg., leaving the balance required to be supplied by electric radiators.

With oil fuel, piping problems become more complex; the air escapes from the amidship tanks are sometimes difficult to handle in way of passenger spaces, an excessive possible head on the tanks being only avoided by taking them out through the shell. Oil fuel galley ranges are also a modern touch in oil-burning ships.

Communication and indicating devices get more complicated, fire-alarm systems, pneumercators, gyro-compass systems and submarine bell listening devices are among the newer modern tendencies.

Better bulkhead subdivision has helped fire protection; with alternates carried up to the top decks, modern ships have been afforded a much better chance of confining and subduing a fire.

The extra boatage now fitted on passenger ships has given trouble. Better bulkheads argue for less boats though "boats for all" is rightly the generally recognised minimum acceptable. The writer feels that more rafts might well be allowed, especially where bulkheads are good.

Compulsory air ports on the lowest passenger deck might well be reconsidered. They can seldom be opened at sea, they are menaces when so opened, and more reliance on good lighting and ventilation from above appears to be a better solution of the question, particularly where cabins replace open steerage quarters. Warships get along very well in that respect, where men are berthed behind armour with no side ports.

The extent to which oil has been substituted for coal as a fuel calls for comment. Lloyd's returns indicate that 22¼ per cent. of the world's total gross tonnage uses oil for propulsion, as compared with 3 per cent. in 1914, a stupendous increase and one that is mainly in vessels of American registry. Correspondingly coal has dropped from 89 per cent. to 72¼ per cent. for the same period. This has resulted in a great increase in oil construction, both for ordinary ships' bunkers and for oil tankers. From the point of view of this paper, the recent conversion from coal to oil of several famous liners is to be noted, also the fact that our ships of the American "Legion" and "Old North State" classes are all primarily oil burners.

Standardisation.—This heading to many here will seem like the beginning of a discussion of the methods of making a series of progressive runs over the measured mile; it does not mean this form of standardisation, but refers to the general one of engineering standards.

It is not necessary to state that a great deal of work has been done of late years, on both sides of the Atlantic, looking to the obtaining of the benefits of standardisation. When in Europe last year I was much impressed by the work done, under Sir Archibald Denny's genial and able leadership, by the British Engineering Standards Association. They have revised their rolled steel section standards, inviting us to co-operate. Some work has been done here along those lines, and this society, with others, has appointed committees to act in conjunction with the American Engineering Standards Committee. As a result of the war we are in much better shape than formerly as regards the obtaining of a wider range of steel sections suitable for shipbuilding and are not without hope of being in better shape yet, once the revival of business brings the exporters to realise the benefits of standardisation.

The British have gone further and are at work standardising ship fittings as far as found practical and desirable; this is a far-seeing step in the maintenance of their shipbuilding position, and one we should not lose sight of.

The work done in the standardisation of marine oil engine construction has been fully covered recently in publications devoted to the internal-combustion engine.

Considerable progress has also been made abroad in standardising steam marine reciprocating engine and Scotch boiler construction, as far as moderate and low powers are concerned. This is advantageous in more ways than one. It facilitates construction and, equally important, it facilitates upkeep. With standard shafts and other parts, which are most liable to need replacement, available the economy to be realised by quick repairs and consequent absence of delay should need no argument before this body.

Anything which helps standardisation along rational lines should have our united support; we have the fleet now to give us the opportunity. Standardisation has been pushed too far in some quarters, but after the exaggerations of the over-zealous have been eliminated, there is still a large field to be covered. The claims for the prompt execution of repairs is one that should not be overlooked; it is an aspect of standardisation that deserves more attention than it has received, though it is largely taken care of by standardised construction.

Referring again to the question of engineering standards the success attending the presentation of the John Fritz medal to Sir Robert Hadfield last summer and the accompanying international engineering conferences constitute another link in the chain leading up to more effective engineering co-operation, which naturally includes standardisation.

Competition and the Future.—Prior to 1914 the British and Germans divided the lion's share of the world's passenger carrying; it is not so now. Germany no longer has a passenger-carrying fleet worthy of the name. Besides ourselves, the ancient empire of the Mikado has now come into a prominent place in passenger-carrying circles, at least as far as the Pacific is concerned. As an indication of the need that still exists for passenger ships, the following table is of interest; its meaning under normal conditions of world intercourse and trade will not necessarily be the same as under present conditions.

World's Sea-Going Tonnage.

——	1914.	1920.
	gross tons	gross tons
Liners and intermediate vessels	13,345,000	12,107,000
Cargo ships	24,935,000	32,518,000
Tankers	1,479,000	42,934,000
Totals	39,759,000	47,559,000

The lines of tied-up cargo ships are well explained by the above figures, which are a variation of Lloyd's regular returns, taken from a paper* read by Mr. Ballard last year before the North-East Coast Institution (England). The shortage in ocean passenger ships is brought out, also the wisdom of the Government in deciding to finish the main programme of war-time transports later converted to passenger ships. In using the word shortage, care must be exercised to discriminate between present and normal times. The strength of our position in cargo-carrying tonnage is not yet reflected in the passenger-carrying trade, but with our operators in the passenger trades encouraged by the delivery of new ships and by the reconditioning of captured vessels, the outlook for the future is brighter than it has been for at least two generations. There is also some encouragement for builders in that the void in their yards caused by the prevailing lack of cargo ship orders may be partly filled by orders for passenger ships.

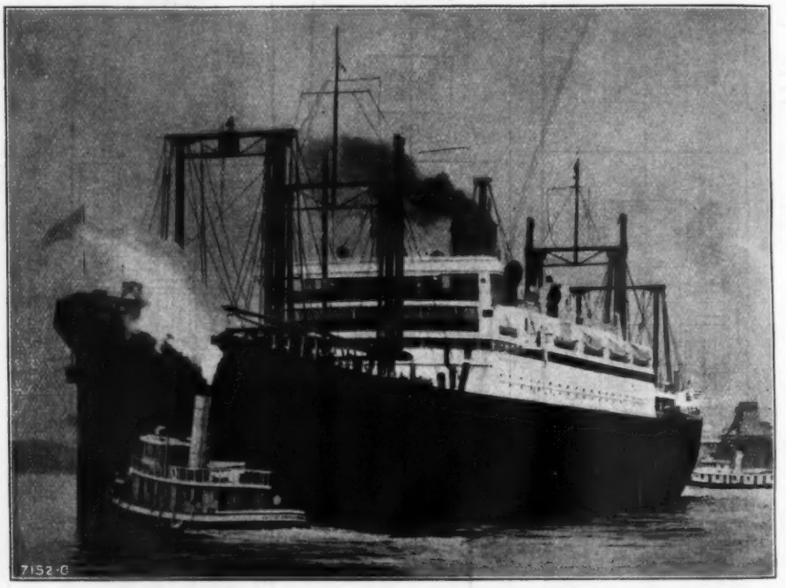


Fig. 15. Ship of the American Legion Class.

Indications are not lacking that our Pacific and South American trades are soon going to become well developed. On the North Atlantic we are not as yet adequately represented. It is true that there are some ships under the flag, but these are not generally of such size and type as to command an adequate share of the trade. The Italians and French have some excellent vessels in that run, notably the new Paris. The Leviathan remains at her dock. Her long idle spell is bad enough, but the lack of policy which kept her not only tied up, but out of condition as well, is a severe blow to our place on the Atlantic. The writer feels that the lack of enterprise in this direction is only temporary; the world will not be content to go backwards in passenger liner development indefinitely.

The Pacific has given one sign of renewed progress in the Empress of Canada. She is almost as much a step in advance over Pacific Ocean average as the Mauretania was in the Atlantic, though this may be held to be somewhat of a stretching of facts. Nevertheless she is clearly a noteworthy vessel, and brings cheer amid the dark clouds of the recent enforced lack of advancement in design. Our new liners will not long occupy any leading place among noteworthy ships, so that our hold on the trade will before long demand larger and faster vessels. The laying down of a 30,000-ton passenger

* See Engineering, vol. cx, page 837 and vol. cxi page 186.

ship by Harland and Wolff for the Holland-America Line is reported, this being the largest vessel commenced in Britain since the war. The end of the retrogression in size appears to be in sight.

In concluding, it seems to be a safe forecast to make that passenger-ship construction will figure somewhat prominently in our bigger and best equipped yards during the next few years, particularly when it is remembered that a considerable number of ships now running would, but for the war, have been out of service ere this and that they will need replacement just as soon as practicable.

WIDENING THE FIELD OF RUBBER MANUFACTURING.

Discoursing on "Widening the Field of Rubber Manufacturing," on December 15, before the Institution of Rubber Industry, Mr. Fordyce Jones, chairman of the Reliance Rubber Company, remarked that the rubber industry was no longer in its infancy, as was often said, but was rather suffering from senile decay, though it seemed once more to be on the upward curve of emergence from a chaotic state. They had to improve their line and to sell more.

While as regards colour Britain was producing some beautiful and some dirty reds, pinks, drabs, greys, and occasionally good non-blooming (*i.e.*, not sulphuring-up) blacks, a clean white being practically non-existent, foreign manufacturers—by which Mr. Jones essentially meant Americans—supplied beautiful blue, bright yellow, tan and chocolate-brown goods. Blooming was fatal to surgical, sporting and domestic rubber ware. The trouble was partly due to the moulds; instead of steel moulds, which he himself had been unable to obtain over here, moulds of cast-iron, aluminium and white metal were largely used, apart from glass and porcelain reserved for exceptional cases.

Another chief impediment referred to was the want of co-operation leading to absurd competition. Trade secrets not worth keeping were still anxiously guarded. The much-discussed over-production of rubber, said to call for a limitation of the output, was less real than the under-consumption of rubber merchandise. The American bath room was full of rubber goods hardly known over here; in America 4½ lb. of pure rubber were manufactured per head of population, against 1½ lb. in this country. There were boundless fields for expansion; to secure that Mr. F. Jones recommended judicious and ample advertising, good shop displays, a rubber newspaper, "educational propaganda"—a rather grand term for proper directions of use—good quality, one best, and one medium, but no more, fair prices, &c.

The discourse was in many respects a severe lecture to British business men which was well received as not undeserved. Technically it was of no importance, and it was rather striking that the rubber needs of electric engineers were not referred to. A suggestion made by Mr. John Gretton, a rubber producer, to standardise rubber goods as to the amount of rubber in them, did not appear to meet with particular favour; a hall-mark for rubber would, of course, be different from a hall-mark for silver, but something of this kind is done in America, and the Institution of Rubber Industry is taking the matter up. Mr. Brooking, president of the Institution, wished to claim superiority at any rate for British rubber tyres; but Mr. F. Jones considered that America leads in that line, certainly as regards tyres for rough roads. One member made the ingenious proposal to replace the corrugated iron roofs which did not keep out the "ultraviolet rays," by roofing of some rubber compound. The lecturer mentioned that the Rubber Growers' Association had recently offered competition prizes for extended uses of rubber; the results had been extremely disappointing.

SLAG IN CONCRETE.

TO THE EDITOR OF ENGINEERING.

SIR,—At intervals there are statements in the Press that cement concrete with slag aggregate has failed after long years of apparently sound life. It is difficult to find instances.

Might I invite your readers to give particulars of such failure to the Building Research Board? The information will be treated as confidential if so desired.

Yours faithfully,
H. O. WELLER,
Director of Building Research.
Scientific and Industrial Research Department.
16 and 18, Old Queen-street, Westminster, S.W.1.
December 19, 1921.

PILE SET GAUGES.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest Mr. Latham's article on the above, on page 684 of your issue of November 18. Mr. Latham does not explain the action of his gauge very fully, and I have difficulty in understanding exactly what the principle is upon which it works. At first sight it would appear to be the inertia of the water in the two vertical limbs of what is equivalent to a U-tube. But on further consideration it is seen that in order that the water in these two limbs may remain behind by inertia, the water would have to separate somewhere at or near the bottom of the U-tube, and to do this it would produce a vacuum there, while the atmospheric pressure would act on the tops of the columns of water, thus tending to force the water down in addition to the pull of gravity; so that apparently the water would by no means remain fixed in space in either limb during the short period of time it takes for the pile to move during the blow of a monkey. It is true an air valve is shown on the right-hand limb of the U-tube, and possibly this may have been introduced for the purpose of "breaking the vacuum" or for producing initial pressure on the top of the water in the right-hand limb, which is closed at the top. If used for the latter purpose, then apparently an unknown tendency may be introduced to cause the water to lift the non-return valve in the left-hand limb, thus introducing an unknown quantity and making the readings unreliable.

I hope Mr. Latham will see his way to explain fully the action of his gauge, and how he overcomes the difficulties which are named therein, including the further one of what effect the recoil of the pile has on the readings of the gauge.

Yours very truly,
H. CECIL BOOTH,
Bridge House, 181, Queen Victoria-street, London, E.C. 4, December 13, 1921.

A copy of the above letter was sent to Mr. Ernest Latham, who has replied to it as follows:—

TO THE EDITOR OF ENGINEERING.

SIR,—I have had the pleasure of reading the above letter from Mr. H. Cecil Booth, M.Inst.C.E., and am gratified at the interest that he with others has taken in the subject.

The possibility of the columns of water separating is to some extent overcome by putting the reservoir side of the U-tube under air pressure, and it is for this purpose that the air valve referred to by Mr. Booth was introduced in the design. As far as I could judge the only effect of this was to magnify the readings of the gauge.

It is desirable to make it quite clear that the right-hand leg of the U-tube is simply and solely a reservoir so as to keep the column of water in the left-hand leg against the valve, *i.e.*, in order that there shall be no air space left after each blow of the hammer.

I agree with Mr. Booth that there are several unknown factors, and I believe the gauge can be very much improved in design. Mr. Ackermann has experimented with gauges in which he uses the mass of a solid instead of a liquid and has reduced his gauge down to a simple and reliable instrument. The recoil of the pile has no effect on the reading of my gauge since the valve being of a non-return design the liquid once trapped cannot pass back.

I admit the matter is a difficult one to explain on paper and, perhaps, with your approval Mr. Booth might get into direct touch with me if he is sufficiently interested.

The difficulty of recording the set of piles was referred to on December 13 by Mr. Hurse, M.Inst.C.E. at the Institution of Civil Engineers, and it is a difficulty all civil engineers experience. Sooner or later I hope the use of a "one-piece" gauge for recording set will become universal practice.

Yours faithfully,
ERNEST LATHAM.

"THE FLOW OF METAL DURING FORGING."

TO THE EDITOR OF ENGINEERING.

SIR,—It seems to me that the whole question of hammering *versus* pressing turns on the time element and temperature. A cone of metal would not be formed in a shell forging if the punch moved slower or if the metal were hotter. In certain conditions of heat and time (either or both) the metal below the punch cannot get out of the way quick enough laterally and so takes the line of least resistance.

Yours truly,
C. G. WATSON.
Crossways, Moorside, Fenham, Newcastle-on-Tyne, December 15, 1921.

"ENGINEERING AS A PROFESSION."

TO THE EDITOR OF ENGINEERING.

SIR,—An anonymous writer of one of the letters which appears in your issue of December 9, among the correspondence on "Engineering as a Profession," states that "The sooner the professional engineers have a union, not an emasculated one like the 'Society of Technical Engineers,' the better it will be for the profession." You were good enough in your issue of September 30 to give sympathetic consideration to the policy of this society as set forth in the September number of its journal, and since that date sundry letters and articles have appeared in various technical organs of the industry in which our policy has been criticised and described as being "emasculate," and which, therefore, suggest a common origin. Whatever that origin may be it would certainly be of interest to this society, and perhaps also of interest to the profession as a whole, if the writer of the letter in your journal in which this criticism occurs, who signs his communication "B.Sc., Assoc.M.Inst.C.E.," will tell us precisely the elements of a "emasculine" policy. What would he do? What would he say? To whom would he say it? What are the immediate results which he would anticipate from his actions and from his sayings? Are we to understand that he would regard it as an essentially "masculine" action if, *e.g.*, all professional engineers banded themselves together and declared a national strike unless the pay of every engineer were increased by, say, 50 per cent. on January 1, 1922? Would he advise an agreement with the engineering foremen to secure that the supervision of the work in progress should not be carried on by those foremen? Would he go a step further and suggest that an agreement should be made with the manual workers so that all work in progress should cease on the date decided on for this national strike? What would he propose to offer to the foremen and to the manual workers respectively as a *quid pro quo* for their support on that occasion? If he would not propose procedure of this order, what is it he has to suggest?

The governing bodies—indeed, one might say the whole of the members of this society—are profoundly convinced that any improvement in the conditions of service and in the resulting efficiency of the technical men in the engineering and allied industries can only be brought about by a most careful survey of the very many problems involved and a most careful consideration of the many possible modes of action. This takes time; things that are worth doing usually do.

The Society of Technical Engineers is slowly getting a clear picture of some of the elements in the conditions of service of professional engineers which need improvement. It is also coming to definite ideas as to the manner in which such improvements may properly be attempted, and while it does not believe that professional engineers would support a policy confined to the attainment of more money for less work, it does believe that an essential element in the whole problem is to be found in the stability of the industry as a whole, and that an element in that stability is an improvement in the understanding between employers and manual workers. It is, moreover, coming to see that the professional engineer should be able to contribute something in bringing about such an understanding.

If that stability can be secured the professional engineer can hope for something better; but until it is secured he will inevitably be as subject to the fluctuations of supply and demand as the employer and the manual worker.

Nevertheless, if "B.Sc., Assoc.M.Inst.C.E.," can provide us with a definite policy on other lines than that which we have outlined, especially if he could suggest in some detail how he would work that policy so that it would yield results such as every professional engineer must desire, it would certainly be of great interest to all engineers, and doubly so to the members and executive of the S.T.E.

Yours faithfully,
NORMAN WYLD,
General Secretary.
The Society of Technical Engineers,
102, Belgrave-Road, S.W. 1.
December 19, 1921.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent "B.A., A.M.Inst.C.E.," does not appear to have read this correspondence with the intelligence and care that one would have expected from his pseudonym, otherwise he would have grasped the following points:—

(1) That it was against the supposed necessity for the *majority* of young engineers to be prepared to go abroad, that we protested. It is obvious that there will always be many young engineers *desirous* of going abroad, and I suppose our Empire was largely founded and maintained by men who have gone voluntarily (the early colonisation of Australia being an exception, but I hope we are not convicts!).

(2) The salary of 350*l.*, which has been freely quoted, was originally stated as the salary offered for a specific post, the qualifications for which *should* be high, and the salary in accordance. At the present time salaries of 300*l.* are offered for men of considerable experience and ability (to judge by the advertisements), and those for junior men show a marked decline since unemployment has become so rife. I am only too well aware of the small salaries at which men started after their training in the past; at sixteen years of age I received the large sum of 30*s.* per week as assistant engineer of a large works, but to say that I was content with my salary would be to overstate the case. A continuance of the present unemployment seems likely to bring about a return to a similar state of affairs, which I have tried to point out is very undesirable. It must not be overlooked that small salaries for men starting a profession, where the number entering every year is large, is apt to mean small salaries for men of greater experience.

(3) I have tried to point out that there is probably scope for the employment of a great many more engineers (in normal times, at least, and probably now). Nobody desires the manufacture of "cushy jobs" or "uneconomical salaries," but few can doubt that there are many works being run uneconomically and unsafely for want of trained engineers.

Finally I am inclined to doubt the benefit of a few years in the Colonies or any other country, where engineering is not so advanced as in our own, to a young engineer.

I think it is rather likely to increase the difficulty of getting suitable employment on his return, as firms will at once say that he is out of touch with the latest practice.

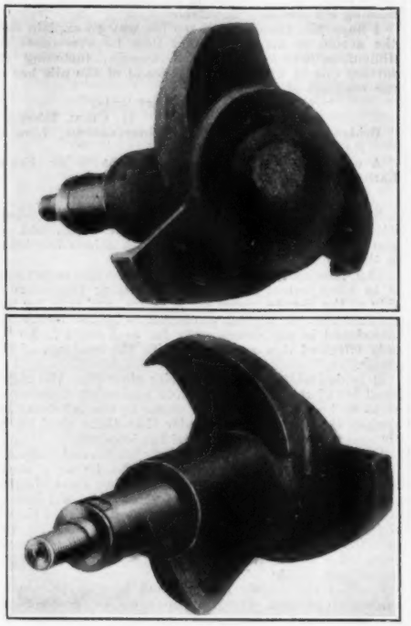
Yours faithfully,
A. C. PURDAY.
December 19, 1921.

MUNICIPAL ELECTRICAL OLD STAGERS.—The suggestion that a re-union of those engaged in municipal electrical work in its early days should be held has met with so remarkably cordial a response that a small committee has been formed to make arrangements to carry it into effect. It is proposed to hold a dinner at the Hotel Cecil on Friday, January 20, at 7 p.m. for 7.30 p.m., the half-hour before the dinner enabling old friends to renew their acquaintanceships. There will be only one toast in addition to the loyal ones, one speaker proposing and two responding. After this it is hoped that some half-dozen "old stagers" will speak on their reminiscences for not more than 5 minutes each, and the party will then adjourn to the reception room for general conversation. Further information can be obtained from Mr. C. H. Wordingham, Secretary to the Committee, 7, Victoria-street, Westminster, S.W. 1.

APPARATUS FOR ELECTRICALLY HEATING LIQUID AND SOLID CHEMICALS.

CONSTRUCTED BY MESSRS. GUTHRIE AND CO., ENGINEERS, ACCRINGTON.

Fig. 1. Step-Ladder Heater.



Figs. 2 and 3. Impeller of Ceratherm Pump.

Fig. 4. Steam-Heated Grinding Pan.

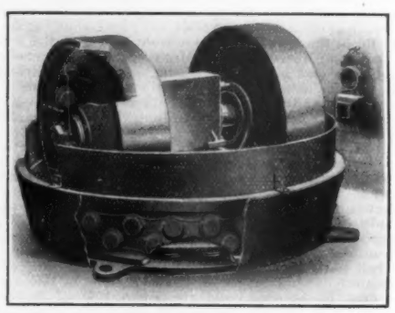
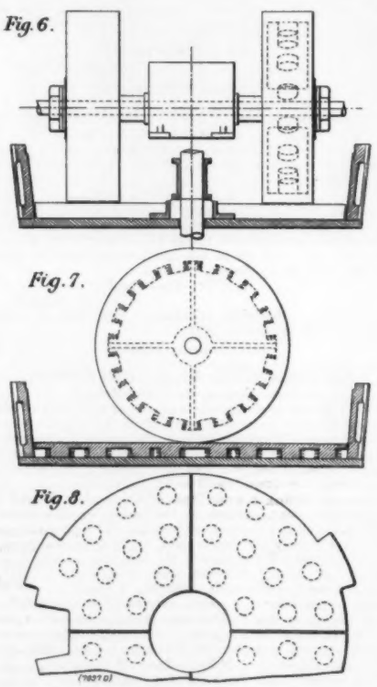


Fig. 5. Electrically-Heated Grinding Pan.

The handling of corrosive liquids and chemicals generally is usually a troublesome operation and any new methods or new plant which may become available will, apart from any direct advantages which it may carry, frequently, by facilitating operation, prove valuable in the saving of labour. This consideration would certainly seem likely to apply to the novel and interesting apparatus for the electrical heating of liquid and solid chemicals which is being introduced by Messrs. Guthrie and Co., of St. James's-chambers, Accrington. Difficulties are not infrequently met in the heating of corrosive liquids for which the use of an oil bath is not always a solution, and Messrs. Guthrie's new electric heater would appear to have advantages of simplicity and convenience, in addition to its qualification of close control of the temperature of the liquid being treated.

In this heater, which is illustrated in Fig. 1 on this page, the liquid is made to flow down a cascade, or step-ladder. An electric current is passed through the liquid itself, alternating current being used to prevent electrolysis, and as the cross-section of the stream is under control and its length may be arranged to suit the particular operation, it is clear that the resistance, and consequently the heating effect, are under control. Further control of the heating may obviously also be obtained by control of the applied voltage. The heating effect is very rapid, and it is of importance to note that the liquid can never be in contact with a surface at a higher temperature than itself, neither can the liquid be heated above its boiling point. The steps or shelves of the step-ladder heater are made of graphite so that any corrosive liquid may be handled, and by discharging to a tank and circulating by means of a pump, as in Fig. 1, any degree of heating may be obtained. The shelves may be arranged either for single-phase or three-phase current. One of the chief advantages of the heater is in the elimination of surfaces of transmission of heat, which are frequently a source of trouble when corrosive liquids are concerned. With such arrangements the liquid has to be exposed to surfaces at a higher temperature than that to which it is desired to take it. Any such necessity is avoided in the step-ladder heater.

In the arrangement shown in Fig. 1 the pump, vat and connecting piping must, of course, be of acid-resisting construction as well as the heater. These conditions are fulfilled by lining the vat with ceramic material and using pipes of armoured porcelain. The pump is of Messrs. Guthrie's "Ceratherm" type, of which a characteristic impeller is illustrated in Figs. 2 and 3. This is formed of "Ceratherm" which is reinforced with steel inside the disc portion when necessary. We described several types of the "Ceratherm" centrifugal pump at some length on page 253 of vol. cx of Engineering, last year, and it is not necessary to refer to it here in any detail. An arrangement of the kind with which we are dealing is useful in connection with the manufacture of certain fast dyes, while in the handling of some starches there are considerable advantages. When using a coil in the ordinary way the temperature of the coil, which is necessarily higher than that of the liquid, is liable to cause bursting of the starch grains with consequent heavy loss. This is entirely obviated in the step-ladder heater. The electrical efficiency of the apparatus as in other electrical heating applications approaches 100 per cent. The cost of heating naturally depends on the liquid being treated and the price of electrical energy, and in various cases works out at from 0·05*d.* to 0·5*d.* per gallon raised from atmospheric temperature to boiling point.



Another interesting and novel application of electric heating to chemical work is an induction surface heating system, and is intended for the drying and heating of solid chemicals. The apparatus generates and maintains the necessary heat within the body of the receptacle within which the chemicals are placed, coils carrying alternating current being arranged in such relation to the surface with which the chemical is in contact that the induced current and hysteresis effect in it generate the necessary heat. Perfect control of the temperature is obtained by the control of the current. This method of heating can be applied to surfaces in drying and other machines which are ordinarily difficult of access, and eliminates the necessity for pressure chambers, or jackets, which both cheapens and simplifies construction. In a machine fitted with this induction arrangement the heating effect is available very rapidly at any time and at the exact spot where it is wanted, while machines may be placed in any situation and nothing more than a cable is required from the outside supply to the heating arrangement.

This form of heating is applicable to both rotary or drum driers, or shelf driers, whether vacuum or otherwise, and will in general not necessitate any modification in the principles of the heater design. An example of an application of this kind is given in Fig. 5. This is a grinding pan for grinding hot. For comparative purposes a steam-heated pan is illustrated in Fig. 4. In this case the plate underneath the roller and the sides of the pan are heated, but in the electrically-heated plant shown in Fig. 5 the rollers themselves are also heated. The distribution of the heating coils in a plant of this kind is more fully shown in the outline sketches given in Figs. 6 to 8. The cost of the heating with an apparatus of this kind naturally depends on the cost of electricity, but it represents a type of service for which the lowest rates are usually quoted, while the questions of simplification and

ROAD AND TRENCH TAMPING AND BREAKING MACHINE.

CONSTRUCTED BY MESSRS. B. JOHNSON AND SON, ENGINEERS, LEEDS.

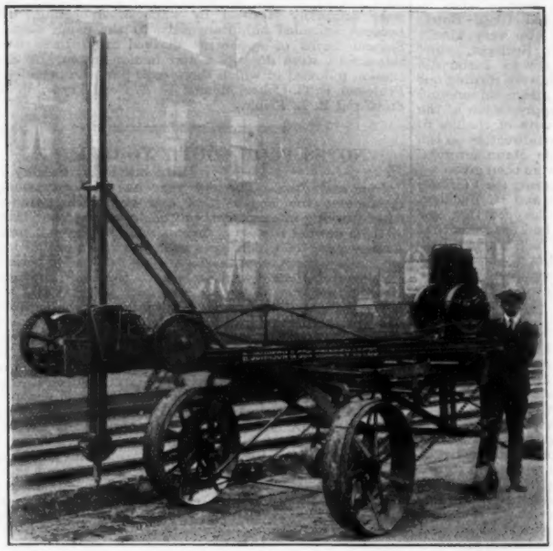


FIG. 1. BREAKING UP OLD CONCRETE TRAMWAY TRACK.

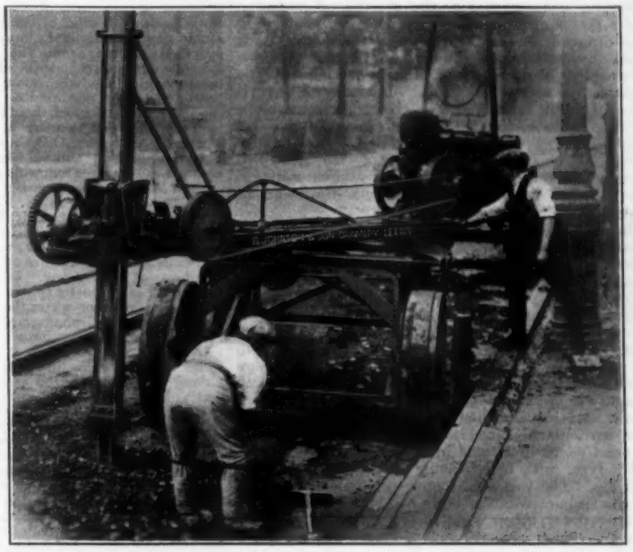


FIG. 2. BREAKING UP ROAD MACADAM.

saving in weight are of importance. In one case of very large grinding mills for hot grinding the weight when steam jacketing was used was about 17½ tons for each pan, but with electric heating the weight was reduced by about 3 tons per set with a corresponding reduction in cost.

This method of induction surface heating has many other applications in chemical engineering as, for instance, in the pumping of sticky or very viscous liquids which have to be maintained at a relatively high temperature in order to keep them in a form which is easy to pump. This is easily accomplished by applying the surface heating system to the pump body. The system is obviously also applicable to delivery pipes, and arrangements of this kind will probably be of considerable interest in, for instance, the chocolate trade. Patents are held or pending in the chief industrial countries for the two electrical heating systems with which this article is concerned.

ROAD AND TRENCH TAMPING AND BREAKING MACHINE.

IN our issue of November 25 last, and in our notice of the Public Works Exhibition, we briefly described a road tamping machine which was exhibited by Messrs. G. Percy Trentham, Ltd., of Winchester House, Victoria-square, Birmingham. Messrs. Trentham are public work contractors, and used the machine on their own contracts. It was constructed by Messrs. B. Johnson & Son, of Bramley, Leeds, whose office is at Wharfedene, Skipton-road, Ilkley, and we now are able in the above figures to give illustrations of two of Messrs. Johnson's machines. Of these two examples that shown in Fig. 1 is engaged in breaking up an old concrete tramway track, and that shown in Fig. 2 in breaking up road macadam. The first machine of this class built by Messrs. Johnson was intended for ramming solid the re-filling of trenches. When it was put on to work it was found possible, in trenches 9 ft. deep, to return all the spoil, and leave a solid road surface, thus saving the cost of carting.

Later machines, in addition to tamping work of this kind, were called on to break shale and soft rock in trench bottoms, and to break macadam 6 in. in advance of excavation, and to tamp the re-fill behind. Cable companies using the machines further required them to break macadam and tamp trenches when the machine was running alongside the trench, as well as when astride it, while tramway contractors wanted it to break up old concrete track. For builders' use the machine was also required to be suitable for tamping the basement and ground floors of buildings before concreting. These various demands, which arose as the machine came more fully into use, resulted in modifications and improvements being introduced as compared with the original model, and the machine as now built will meet all the conditions specified above. The actual tampers shown in our two illustrations are not the final model as now built, but the differences are of a minor nature, and the figures show what is substantially the latest form.

The machine will tamp any size of trench up to 4 ft. wide and 16 ft. deep when it is running astride the trench and 3 ft. wide by 16 ft. deep when it is running alongside the trench. On surface tamping the machine will work over a track 8 ft. 6 in. wide in advance of itself. The tamping weight is 150 lb., the stroke of the head is 24 in., and 55 blows a minute are struck. The machine consists of a road carriage on which a swivel is mounted, which carries the tamping head and the engine driving it. This swivel is made of steel channels, and is mounted near its centre of gravity on a saddle casting carrying a pivot. The swivel swings in an horizontal direction on the pivot bearing, and thus moves the tamping head across the work. Movement along the work is obtained by traversing the carriage forward. The saddle casting which carries the centre pivot is fitted with a lead screw and nut, and can be traversed across the carriage, so allowing the tamping head to operate on a trench alongside the machine. The swinging of the swivel and the consequent command of a large area by the tamping head will be clearly understood from Fig. 2.

The tamping head consists of an ash board reinforced by small steel channels on each edge, and sliding in long steel guides. The lower end of the board carries the tamping face, and to this tools can be attached for breaking macadam or similar work. A single chisel is used for concrete or rock, and a double chisel for macadam. The board is held up, as shown in Fig. 1, by two eccentric grips, which are actuated by a bell-crank and a link connecting to the engine end of the machine. In this condition the grips are pressed against the lifting board by a spring acting on the bell-crank, but when the plank is being operated the grips are held out of contact by a latch near the operator's end of the link. The lifting mechanism consists of a parallel faced plain pulley part of the circumference of which is cut away. The pulley face is pressed against the board by a coiled spring, and as the pulley revolves it lifts the board owing to the friction grip. When the cut-away part of the pulley comes around, however, the board is released and drops by its own weight. This happens once for each revolution of the pulley. The tamping head drops quite freely, and the blow is given without any shock or strain being transmitted to the machine.

When it is desired to stop the action of the lifting board without stopping the engine, the latch is pushed forward, and the grips prevent the board from falling. As the lifting face of the pulley comes round, however, it lifts the board the length of the stroke at each revolution. Towards its lower end the board is reduced in thickness, and when it has been lifted to such a height that this reduced section comes opposite the lifting pulley, the pulley fails to grip it, and it is lifted no higher. During this condition, however, the grips still hold it until they are released by the operator. By operating this arrangement the machine may be made to give a single blow. If the grips are kept out, the board, of course, is continually lifted and falls as before described. This tamping mechanism is driven by belt from the engine, which is carried at the other end of the swivel, and balances the tamping head. The belt drive is clearly shown in our figures. The engine, which is English-built, is of 2½ h.p., and is arranged to start on petrol, and run on paraffin. If petrol alone is used the consumption is 1¼ gallons a day.

The carriage on which the machine travels is built of angle bars and plate verticals. The road wheels are made of wrought iron, and are 36 in. in diameter. The rims are 8 in. wide, and an extra tyre 4 in. wide is fixed round the middle of the tread. The two swivel wheels are of cast iron. A vertical adjustment is provided for all wheels, so that when required to work on any unlevel surface the wheels can be lifted to suit the conditions. As will be gathered from the figures, in the machines we illustrate the road wheels are driven by chains, but in the latest model the final drive is by a spur gear on the travelling wheels, driven by a spur and bevel differential intermediate, which in turn is actuated by a roller pitch chain. The whole arrangement is driven by a handle at the end of the truck. An extra slow travelling motion working through a worm gear is also provided. This can be operated either from the end or side of the carriage, as desired, and enables the machine, when tamping, to be easily and continuously moved forward and worked by one man. The total weight of the machine is 28 cwt.

DANISH SHIPBUILDING.—Two more Danish shipyards have gone into liquidation, and almost all the provincial shipbuilding establishments started during the war have been faring badly lately. The depression, if anything, has become more pronounced, the number of unemployed is increasing, and the legislative measures recently brought forward by the Government do not, by any means, come up to what the industrial world in Denmark had hoped for, or considered expedient.

GAS MANTLE DIFFICULTIES DURING THE WAR.—Dr. Geisel, of the Auer Gesellschaft, recently described some of the difficulties which the scarcity of materials caused to the manufacturers of gas mantles in Germany during the war. All the raw materials were imported. The stock of thorium and cerium minerals was ample. But ramie was scarce, and the artificial silk used in its place gave out in 1918; paper fibre was then tried, finally with moderate success. Long asbestos fibres for drawing the ends of the threads together not being obtainable, the short fibres, formerly rejected, were used, and when they could not be procured any longer, iron wires were used; they answered because the gas was very poor by that time. In place of collodion and camphor it was found necessary to substitute the various phenol condensation products.

ELECTRIC LOCOMOTIVES FOR THE PAULISTA RAILWAY OF BRAZIL.

As Brazil has considerable natural resources in water power and as most of the coal used in the country is imported, it is matter for no surprise that increasing attention is being paid to the question of operating the railways electrically. The latest development in this direction is the equipment of the double track main line between Jundrahy and Campinas of the Companhia Paulista de Estradas de Ferro. The distance is about 28 miles. Jundrahy, which is about 90 miles from Santos, is the southern terminus of the Paulista system. It here joins to the Sao Paulo Railway which runs to the coast at Santos. From Campinas, the other end of the electrified section, an extensive metre gauge system radiates. The line is equipped for 3,000-volt direct-current operation, with overhead collection.

In connection with this electrification the Westinghouse Electric International Company is supplying four electric locomotives, two for goods and two for passenger work. Illustrations of each type, which we reproduce on page 856, were shown by Mr. W. R. Stinemetz in connection with a paper read before the Canadian Railway Club, at Montreal, on November 8 last. Further details of these machines were given in an article by Mr. S. B. Cooper, of the Westinghouse Electric and Manufacturing Company, which appeared recently in *Railway and Locomotive Engineering* of New York. We are indebted to Mr. Cooper's article for our particulars of the locomotives. The passenger locomotive, as illustrated in Fig. 1, is of the 2-4-0 + 0-4-2 type, with each driving axle equipped with a 580 h.p. 3,000-volt twin motor and quill drive. The goods locomotives, as shown in Fig. 2, are of the 0-6-0 + 0-6-0 type, with two six-wheel articulated trucks. There are six axle-mounted motors rated 280 h.p. for one-hour rating. Each motor is wound for 1,500 volts for operation two in series on 3,000 volts. Each motor drives its axle by a single flexible gear.

This arrangement of motors fits in particularly well with the requirements of the road. The passenger and goods train weights and schedule speeds require locomotive horse-power ratings in almost exact ratio of four to three, so that using eight armatures on the passenger locomotives and six on the goods locomotives it was possible to use identical motors throughout, except for the external frames. This is, of course, a considerable advantage from an operating point of view. The passenger locomotive motors are in twin frames, while the goods locomotive motors are in axle and nose suspension frames. All replacement parts, coils, armatures, brushes, &c., are interchangeable throughout. The passenger locomotives operate at speeds up to 65 miles an hour and have the advantage of high centre of gravity and a large proportion of spring-borne weight. The goods locomotives operate up to speeds of 40 miles an hour, and with comparatively light axle loads have the mechanical simplicity of axle-mounted motors and direct-geared drive. As the Paulista Railway uses open coupling links on its goods stock it was desirable to have a high degree of flexibility and smoothness in the control. This is arranged for by having three motor combinations of six, three and two armatures in series giving, with field control notches, six running speeds. The main handle on the master controller has eighteen positions, giving a total of fifty-four notches. On the passenger locomotives the armatures are connected eight, four and two in series, giving six running speeds and fifty-four notches.

Regeneration is provided for in all three combinations, with thirteen notches in each combination. This gives a wide range of regenerating speeds, which is a desirable feature, owing to the various classes of trains and the various grade conditions on the railway. The passenger locomotives have a total length over buffers of 52 ft. 11 in. and a height over the cab roof of 12 ft. 7 in. The total height with the trolley down is 14 ft. 10 in. The total wheel base is 42 ft. 2 in. and the rigid wheel base 8 ft. 4 in. The driving wheels are 63 in. in diameter. The goods locomotives are 50 ft. 2 in. long over buffers, and the heights are the same as given above for the passenger locomotives. The total wheel base is 37 ft. and the rigid wheel base 14 ft. The driving wheels are 40 in. in diameter. The respective weights of the passenger and goods locomotives are 128 metric tons and 106 metric tons. The weights on the driving wheels are 93·5 metric tons and 106 metric tons.

The British Electrical and Allied Manufacturers' Association.—This association, which is incorporated, has, on the recommendation of its Education Committee, recently granted the following scholarships, each tenable for one year and each carrying a maintenance allowance of 100*l.* and the payment of college fees: In electrical engineering (steam turbo-generators), three scholarships, and in mechanical engineering (steam turbines), also three scholarships.

SOCIETY OF GLASS TECHNOLOGY.

The forty-eighth general meeting of the Society of Glass Technology was held in University College, London, on Wednesday, December 14, when the president, Dr. Morris W. Travers, F.R.S., occupied the chair. During the forenoon, by the courtesy of the directors, a party of some 60 members of the society paid a visit to the Charlton Works of Messrs. United Glass Bottle Manufacturers, Limited, lunch being also very kindly provided. Apart from the oil-fired furnaces, chief interest centred round the 10-arm Owens automatic bottle-making machines, some of which were turning out nearly 60 bottles per minute. At the afternoon meeting the members expressed their cordial appreciation of the facilities accorded them in a hearty vote of thanks to Mr. G. E. Alexander, O.B.E., and his co-directors on the Board of Messrs. United Glass Bottle Manufacturers, Limited. The three following papers were then given:—

(1) "*A Suggested Method of Investigating the Viscosity of Glass*," by J. Masson, N. F. Gilbert and H. Buckley. In presenting this paper Mr. Gilbert observed that few methods were suitable. The one they had used was that of dropping a metal sphere, usually a ball bearing, into a viscous substance such as syrup, and applying a modified form of Stokes' law. Occular measurement of the rate of fall of the metal sphere agreed fairly well with the X-ray measurement where the shadow of the sphere was projected on to a photographic plate. In the case of molten glass, alundum crucibles had been found quite satisfactory, with platinum or large nickel balls. Lantern slides were shown to illustrate the method. Dr. Masson having also spoken, the president, Mr. F. Twyman, and V. H. Stott took part in the discussion that followed.

(2) "*Note on Pipettes*," by Verney Stott, B.A. (National Physical Laboratory). This paper was illustrated by lantern slides, the conclusion arrived at being: (*a*) Pipettes should be adjusted for a particular delivery time, and when testing pipettes it is important to record both the delivery time and capacity; (*b*) the delivery time should be within certain limits as pipettes are unsatisfactory if the delivery time is too short, and also if it is too long; (*c*) a definite period should be allowed for drainage, when graduating, testing and using pipettes. The President, and Messrs. Towers and A. Stevenson, contributed to the discussion that followed.

(3) "*On the Annealing of Glassware and on Annealing Without Pyrometers*," by F. Twyman. This paper, which was illustrated by lantern slides, experiments and demonstrations, gave an account of some work done since the reading of a paper on "Annealing" before the Society in February, 1917. It was based on the assumption that so far as the practical annealing of glassware was concerned, the problem was simply one of the release of strain in a highly viscous liquid. There were two difficulties involved in determining the annealing temperature of a glass from its viscosity. The first is fundamental. If E is the modulus of elasticity, T the time of relaxation, then the viscosity is $E \times T$. But the time of relaxation cannot be determined from the viscosity unless at the same time the modulus of elasticity be known, and data are not available for the modulus of elasticity of glasses at temperatures within the annealing range. At the same time, glasses do not enormously vary their moduli of elasticity as the temperature is raised, and a very big change of modulus of elasticity would be necessary to cause any important difference of annealing temperature. The second objection is of a practical nature. In determinations of annealing temperatures which are obtained by means of measurement of viscosity, it is necessary to measure the temperature at which the viscosity of the given glass has an observed value. This requires a pyrometer, and a small easily-controllable furnace.

The method proposed removes both these objections, and is based on Maxwell's expression for the removal of strain in viscous solids. If we define the desired state of annealing by saying that we require the stresses originally present to be reduced in a particular proportion we may write as original stress F_0 and we then have the proportion of stress left in the glass at the end of time t,

$$\frac{F}{F_0} = e^{-\frac{t}{T}}$$

T being the time of relaxation.

If, now, we can observe, during the process of annealing, the proportion of stress left in the glass (compared with that present before the process commenced) from time to time, we can stop the process when that proportion has arrived at a sufficiently small fraction, say one-tenth or one-twentieth, and nothing further is necessary. In stating the problem thus we no longer rely on Maxwell's law, but merely assume that $\frac{F}{F_0} = f(t)$ when $f(t)$ does not depend on the stress. Now, although we cannot conveniently observe the stress F on the objects themselves during annealing, we can do something nearly as good. A piece of the glass required to be annealed (which piece may be of any shape and size) so long as it is possible to deform it elastically by a comfortably perceptible amount) is introduced into the furnace among the articles to be annealed. It is elastically strained by a definite amount, sufficient stress being brought to bear to deform it to that extent, and is in this way brought to an artificially unannealed state. Periodically the stress is removed, and it is allowed to spring back if it will to its original shape. As the temperature of the furnace is raised, a time will come when the test-piece does not spring back entirely, and from a record of the time during which the piece has been kept strained at a particular temperature and the extent to which it recovers its original position, it would be possible if desired, to calculate the time of relaxation at the temperature. But for practical purposes that is not necessary, for if it springs back on release by one-half its originally strained amount, we know that it has been half annealed; if to one-tenth it is 90 per cent. annealed, and so on, and this time is quite independent of whether the lehr has been kept at a constant temperature during the annealing or not. And if the test-piece deliberately strained is thus annealed, then the other objects which have passed through the same temperature history, and were originally strained by want of annealing, will become annealed simultaneously to the same degree. Several forms of apparatus derived from these considerations were described and demonstrated. A discussion followed in which there took part the president, Professor E. G. Coker, Messrs. E. A. Coad-Pryor, V. H. Stott and R. L. Frink.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The old year has finished tamely throughout the heavy steel and engineering trades. After working intermittently at one-quarter to one-third of their normal capacity, forges, rolling mills and press shops—many of which have been run at an actual loss for the last three months—have closed down for periods varying from four days to a week. Hopes of improvement in the New Year are generally entertained, but there is a wide feeling among the largest manufacturers that any improvement in the near future will be of a slow character, and that some of the heavier industries will not regain a sound basis until another twelve months or more has elapsed. The bottom has not been reached in price movements. Most secondary grades of iron and steel, both raw and semi-finished, are cheaper, but users are not buying heavily, because their home contract requirements are light, and prospects are not sufficiently well-defined to warrant a heavy expenditure, even if the cash was available. Automobile engineers are taking rather a heavier tonnage of steel, and there are signs of improvement in trade in farm implements, tools and cutlery with Ireland. Manufacturers are moving very cautiously in the production of the new stainless iron. Its possibilities have not been sufficiently tested to warrant extravagant claims. One satisfactory feature is a further diminution in the tonnage of foreign iron and steel coming into the South Yorkshire district. As old contracts are being worked off, local buyers are resuming British connections. There is still an abundance of cheap scrap, but the inquiry is more robust, and merchants are less disposed to contract at greatly cut rates.

South Yorkshire Coal Trade.—The position is a shade better. On the export side the demand for best steam hards is a little healthier, though business with home users is still greatly restricted. Cobbles and nuts are weak. A sustained improvement in slacks is directly traceable to the fact that prices of this grade are more in proportion to pre-war values in comparison with better quality fuel. Cokes of all sorts are only a slow market. House coal merchants are doing more business, but are able to meet requirements on day-to-day deliveries. Quotations:—Best branch handpicked, 39*s.* to 40*s.*; Barnsley best Silkestone, 38*s.* to 40*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 27*s.* to 29*s.*; Yorkshire hards, 29*s.* to 30*s.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 15*s.* to 16*s.*; smalls, 5*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The output of Cleveland pig-iron is on a very limited scale, but it is more than ample for current needs. That there is confidence in the future, however, is emphasised by the announcement that two idle furnaces are being re-kindled, which will increase the number in operation to seven. It is fully recognised that little movement in the direction of increased demand would quickly take up all the available supply of the better qualities of Cleveland pig-iron. For home purposes, No. 1 is 105*s.* and No. 3 G.M.B. 100*s.*, and for despatch to foreign destinations the former is 110*s.* and the latter 105*s.* The inferior grades are very plentiful and are much pressed on the market, makers being keen sellers on both home and export account at 95*s.* for No. 4 foundry, 90*s.* for No. 4 forge, and 85*s.* for mottled and white.

Hematite.—Though East Coast brands are the cheapest hematite in the country, a distinctly easy feeling in this branch is no more than can be expected with production a good deal in excess of present requirements. At the same time a feeling prevails that ere long sales will be less difficult to arrange. Makers are not hampered by any restriction fixing prices on one level, and having a free hand as to charges some firms are not averse to giving favourable consideration to offers at rather below recognised market rates. There are 11 furnaces running on hematite. Nos. 1, 2 and 3 are on sale at 102*s.* 6*d.*, and No. 1 is half-a-crown above mixed Nos.

Foreign Ore.—Business in foreign ore is all but at a standstill, consumers having considerable stocks, and large quantities yet to take out against old contracts, so that they are quite independent of the market. Best rubio is in the neighbourhood of 26*s.* c.i.f.

Coke.—Coke presents no new feature of moment. Local users continue to hold off in anticipation of securing better terms than are at present obtainable, and report that forward purchases can be made at a few shillings below prompt prices. For early business, Durham blast-

furnace coke, of average quality, is quoted 28*s.* to 29*s.*, delivered.

Manufactured Iron and Steel.—Production of manufactured iron and steel is now very small, and new business is on a trifling scale, offers of manufacturers to accept orders at below cost to keep plant partially employed failing to attract customers to any extent. Despite the fact that makers have reached almost the limit of sacrifice, there is much reason to conclude that prices will have to be again lowered. Common iron bars are 12*l.* 10*s.*; iron rivets, 14*l.* 10*s.*; soft steel billets, 7*l.* 10*s.*; medium steel billets, 9*l.*; hard steel billets, 9*l.* 10*s.*; steel boiler plates, 16*l.*; steel ship bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 14*l.* 10*s.*; and corrugated galvanised sheets, 17*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The announcement of the railway companies reducing the rates on coal, coke and fuel by 25 per cent. was received with disappointment by traders as the reduction was regarded as too infinitesimal to bring about a revival in trade. In reality the average reduction which takes place on January 1 is only about 15 per cent. below the present charges, and will be still more than 100 per cent. above the pre-war charges. In the case of a pre-war charge of 1*s.* the new charge will be 2*s.* 1*d.*, which is 5*d.*, or 16 per cent. less than the current rate of 2*s.* 6*d.* There was a further fall in the average export price of large coal shipped in November, but an increase in respect to smalls. Large steams shipped from Cardiff averaged 30*s.* 11*d.*, compared with 32*s.* 8*d.* in October and small 17*s.* 2*d.* against 16*s.* 8*d.*, large, shipped at Newport, 31*s.* 2*d.* against 31*s.*, and small 20*s.* 9*d.* against 20*s.* 1*d.* At Swansea large averaged 28*s.* 10*d.* against 31*s.* 4*d.* and small 20*s.* 10*d.* against 19*s.* It is reported that the Indian inquiry for 250,000 tons of large coal delivery over two months, has fallen through, and that another inquiry is in the market for a similar quantity over the whole of 1922. The Argentine railways are also asking for tenders for 100,000 tons of large and small coal over next year. Meanwhile the market is steady. Most collieries are fully stemmed on paper, and are asking 25*s.* 6*d.* to 26*s.* for best Admiralty large, and 19*s.* for best steam smalls, but with tips scarce at the docks, buyers able to take quick delivery can secure discounts of about 6*d.* Foreign cargo exports in the past week totalled 484,896 tons, of which 199,540 tons went to France, 52,382 tons to Italy, 85,712 tons to South America, 25,110 tons to Spain, 13,852 tons to Portugal, 648 tons to Greece, 46,040 tons to British coaling depots, and 61,612 tons to other countries.

Iron and Steel.—With the approach of the holidays there has been a slackening off in interest. Liquidation of speculative purchases has caused further weakness in prices, which are now round 20*s.* 9*d.* for prompt plates and 20*s.* 1½*d.* forward. With more mills coming into operation and supplies increasing it is anticipated that prices will further recede.

THE CROMPTON MEDAL.—A general meeting of the Institution of Automobile Engineers was held on Wednesday, the 14th inst., when the Crompton Medal, awarded annually for the best paper of the session, was presented to Mr. H. L. Heathcote, M.Sc., F.I.C., Chief of the research laboratories, Rudge-Whitworth, Limited, Coventry, for his paper entitled "The Ball Bearing in the Making, under Test and on Service," which was read at the meeting of the Members of this Institution on April 27, 1921.

BRITISH PRODUCTION OF PIG-IRON AND STEEL.—The production of pig-iron in November showed a further slight rise to 271,800 tons (compared with 235,500 tons in October), but is still much below the production immediately before the coal stoppage and less than 40 per cent. of the production in the autumn of 1920. Only 85 furnaces were in blast at the end of the month compared with 82 at the beginning of the month, two having suspended and five resumed operations during the month. Before the stoppage 109 furnaces were in blast, and in the autumn of last year over 300. Of the pig-iron produced 90,300 tons were hematite, 80,500 tons basic, 79,100 tons foundry and 15,000 tons forge. The production of steel in November amounted to 442,800 tons, the highest output attained since February, but only 50 per cent. of the production of September, 1920.

TOKIO PEACE EXHIBITION.—The Department of Overseas Trade is in receipt of information from the Commercial Counsellor of H.M. Embassy, Tokio, regarding the forthcoming Peace Exhibition which is to be held there from March 10 to July 31, 1922. The Commercial Counsellor states that this Exhibition may prove a good opportunity for showing new British goods, and he recommends British firms to make a small exhibit. It would appear that all the space available for foreign exhibits has been over-applied for. Messrs. Arthur Buckney and Co., Tokio, have, however, secured a special site for the erection of a British pavilion, and intending exhibitors can obtain space therein on application to the London office of the firm, 40, Westminster Palace-gardens, Victoria-street, S.W.1. Rebates of freights on goods for exhibition have been arranged by Messrs. Buckney, ranging from 20 per cent. to 50 per cent., according to date of shipment. Intending exhibitors should lose no time in communicating with Messrs. Buckney, who are prepared to arrange all details, supply attendant staff at Tokio, and safeguard exhibitors' interests in every possible way.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There is practically no change to report in connection with the Scottish steel trade this week, and producers are all crying out for orders. The business passing is mainly of a hand-to-mouth description, and nothing is ordered on until it is actually required, with the result that the keeping of the works running is a matter of no little difficulty. There is much talk here of a revival in trade in the beginning of the year, but there are few signs to point to that optimistic spirit. Oncost charges have been easing off slightly, and as prices generally are tending downwards, the outlook is certainly a bit better, but buyers are not inclined to operate until they consider prices have reached rock bottom. The demand for plates and sections from the shipbuilding industry is of very small dimensions as almost no new tonnage has been booked for many months. Boiler plates are also very slow, and black and galvanised sheet makers are not doing much business for the home market. The inquiry for sheets for export has been fairly good of late, and that branch of the industry is expected to open out before very long. The general export trade is, however, very poor meantime, and financial conditions abroad are retarding business to a certain extent. Prices all round are nominally unchanged, but for favourable specifications sellers are very ready to negotiate in the hope of securing business to keep their establishments running. Competition continues keen.

Malleable Iron Trade.—A considerable amount of unemployment is still general in the West of Scotland malleable iron trade owing to the great scarcity of orders. The increase in the number of inquiries which has been noticeable of late has not brought forth an increase in trade yet, although there would seem to be good prospects of an opening out in the near future, but to what extent remains to be seen. Prices are unchanged round the basis figure of 12*l.* 10*s.* per ton for "crown" bars delivered Glasgow.

Scottish Pig-Iron Trade.—The conditions in the Scottish pig-iron industry have not varied during the past week, but the demand is, if anything, rather smaller. The output has again been curtailed, as several more furnaces have been blown out, and the half dozen or so still in blast seem quite capable of overtaking all the current demand, which is very light. Stocks which were beginning to accumulate at makers' yards are being gradually cleared off. There has been an improvement in inquiry, and with prices tending downwards there are prospects of more business coming the way of the ironmasters before long. Quotations are nominally without change, but producers are very willing to come and go a bit if business is likely to be forthcoming.

ERRATUM.—The title of the last book mentioned under "Books Received" on page 816 should read "*Calcul Pratique des Poutres Continues en Béton Armé en tenant compte de la Raideur des Colonnes*," par G. MAGNEL.

BOARD OF EDUCATION SCHOLARSHIPS.—The Secretary of the Board of Education has issued the time-table of examinations which are to take place in a number of subjects in 1922, commencing on May 8. The time-table is Form 67 U, and it can be obtained from the Board.

THE FARADAY SOCIETY.—At the annual general meeting of this society, held on the 13th inst., the following officers and council were elected to serve for the forthcoming year:—President: Professor Alfred Porter, F.R.S. Vice-presidents: W. R. Cooper, Professor C. H. Desch, Professor F. G. Donnan, F.R.S., Dr. J. A. Harker, E. Hatschek, Professor T. M. Lowry, F.R.S., and Dr. G. Senter. Treasurer: Robert L. Mond. Council: Professor A. J. Allmand, Dr. H. Borns, Cosmo Johns, Professor W. C. McC. Lewis, Professor J. R. Partington, C. C. Paterson, Dr. J. N. Pring, Professor A. O. Rankine, Dr. E. K. Rideal and Sir Robert Robertson, K.B.E. The work of the society had greatly expanded, and an appeal was made for an increased membership, without which it would be difficult for the society to keep pace with its increasing activities without a higher subscription. Up to the present an increase has been avoided.

BRITISH STUDENTS IN FRANCE.—We are informed by the British Section of the Société des Ingénieurs Civils de France that French engineering firms in the Lorraine district, manufacturing rolling-stock, railway material, &c., have kindly consented to employ a few British engineering students for periods of from two to three months during their summer holidays. Applications in writing, stating age, qualifications and giving references will for the present be received by the Hon. Secretary of the British Section, 45, Great Marlborough-street, W.1. The students will not receive any salary and will have to make their own arrangements for the journey, board and lodging, but local members of the Société are prepared to advise in these matters. The students, in their own interest, will undertake to submit to the same discipline and working hours as their French colleagues on the works' staff. Some knowledge of the French language is advisable. We welcome with great pleasure the opportunity which is here afforded of enabling many of our young engineering students to perfect their knowledge of the French language and to enter into bonds of friendship with numerous French colleagues, whilst improving their insight in the industry they have selected for their life's work. The British Section, in its action in this particular instance, has given a further proof of its vitality, and is to be heartily congratulated.

NOTICE OF MEETING.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, December 30, at 7.30 p.m., at the Institution of Mechanical Engineers, Storey's Gate, London, S.W. Mr. G. H. Hales, A.F.R.Ae.S., M.I.P.E. (Member of Council), works manager of Messrs. Drummond Brothers, Limited, Guildford, will deliver a paper, to be illustrated by lantern slides, dealing with "The Costing System and its Relation to Production."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 30, at 8 p.m., at Caxton Hall, Questions and General Discussion.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 6, at 6 p.m., Joint Meeting with the Society of Chemical Industry. "The Co-operation of the Engineer and Chemist in the Control of Plants and Processes," by Mr. G. M. Gill, Member.

CITY RAILWAY EXTENSIONS IN SYDNEY.—City railway extensions estimated to cost 4,500,000*l.* are to be proceeded with in Sydney, New South Wales, in order to relieve the existing rail and tram services. In 1905 the tramways on the southern shore of Sydney Harbour carried 120,973,934 persons; in 1920 the number had risen to 269,255,033. Directly and indirectly the extensions authorised should provide employment for 5,000 men.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Owing to the short time available for the discussion of Mr. H. F. L. Orcutt's paper on "Gear Boxes," which was read before the London centre on the 14th inst., it has been decided to hold a meeting at the offices of the Institution at 28, Victoria-street, Westminster, S.W. 1, on Thursday next, the 29th inst., in order to give those unable to speak at the previous meeting an opportunity of doing so. We commenced to reprint this paper on page 830 of our last issue and the continuation will be found in this issue on page 870. We are informed that the Daimler premium of 25*l.* has been awarded to Mr. E. L. Bass for his paper on "Engine Lubrication," which will be read before the London centre at a meeting to be held on February 8, 1922.

OIL IN AUSTRALIA.—A cheap and effective process for the extraction of oil is now being applied to some of the shale deposits which Australia possesses in large quantities. At Joadja and Reedy Creek, near Mittagong, New South Wales, the Oil Shale Products and Coal Company, Limited, after two years experimenting, is using a dry distillation process from which a return of 100 gallons of crude oil to the ton is being obtained. A similar process in Scotland pays dividends on the basis of 20 gallons of crude to the ton of shale. The field of operation in Australia is about 90 miles from Sydney, and consists of 6,000 acres with a practically unlimited supply of shale. The quality of the oil is excellent, giving better test results than any imported oils. Large development of the industry is certain, and motor traders and others are keenly interested. This news is probably a foreshadowing of the future course that oil-production in Australia is destined to take, solid oil-bearing shale being abundant and fluid oil rare.

LOWER RAIL PRICES IN THE UNITED STATES.—A matter of paramount interest to the steel industry, says *Iron and Steel of Canada*, developed recently in a reduction in the price of steel rails by the United States Steel Corporation, which announced that its subsidiary companies would lower the price of open hearth rails to 40 dols. per ton, which means a rather sharp cut of 7 dols. per ton. Nothing was said about the Bessemer product, but it is presumed that the old differential of 2 dols. per ton will be maintained, which will bring the prices now current by the leading interest down to 38 dols. and 40 dols. respectively. The reduction, it was announced, had been made without reference to the cost of production, which, it was hoped, would be rectified by lower freight rates and increased business. How far the independents will go in the matter of meeting the competition of the leading producer will be watched with eagerness. It may be presumed that the new price at least will become general. The railroads have been buying a few rails urgently needed, but the 1922 requirements had not been placed pending a price readjustment.

THE PHYSICAL SOCIETY AND OPTICAL SOCIETY'S ANNUAL EXHIBITION.—This exhibition, which is to be held on Wednesday and Thursday, January 4 and 5, at the Imperial College of Science, South Kensington, will be open in the afternoon (from 3 p.m. to 6 p.m.) and in the evening (from 7 p.m. to 10 p.m.). Mr. A. A. Campbell Swinton, M.Inst.C.E., F.R.S., will give a lecture on "The Johnsen-Rahbek Electrostatic Telephone and its Predecessors," at 4 p.m. on January 4, and at 8 p.m. on January 5. Mr. F. Harrison Glew will give a lecture on "Radium; Its Application in Peace and War," at 8 p.m., on January 4, Professor F. J. Cheshire, C.B.E., will take the chair. The lectures will be illustrated by experiments. Over 50 firms will exhibit scientific apparatus, and a number of experimental demonstrations have been arranged. Admission in all cases will be by ticket only, and therefore members of other societies desiring to attend the exhibition should apply to the secretary of the society to which they belong. Others interested should apply direct to F. E. Smith, F.R.S., Hon. Secretary of the Physical Society, Admiralty Research Laboratory, Teddington, S.W.

ELECTRIC LOCOMOTIVES FOR THE PAULISTA RAILWAY OF BRAZIL.

CONSTRUCTED BY THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, PITTSBURG, U.S.A.

(*For Description, see Page* 854.)

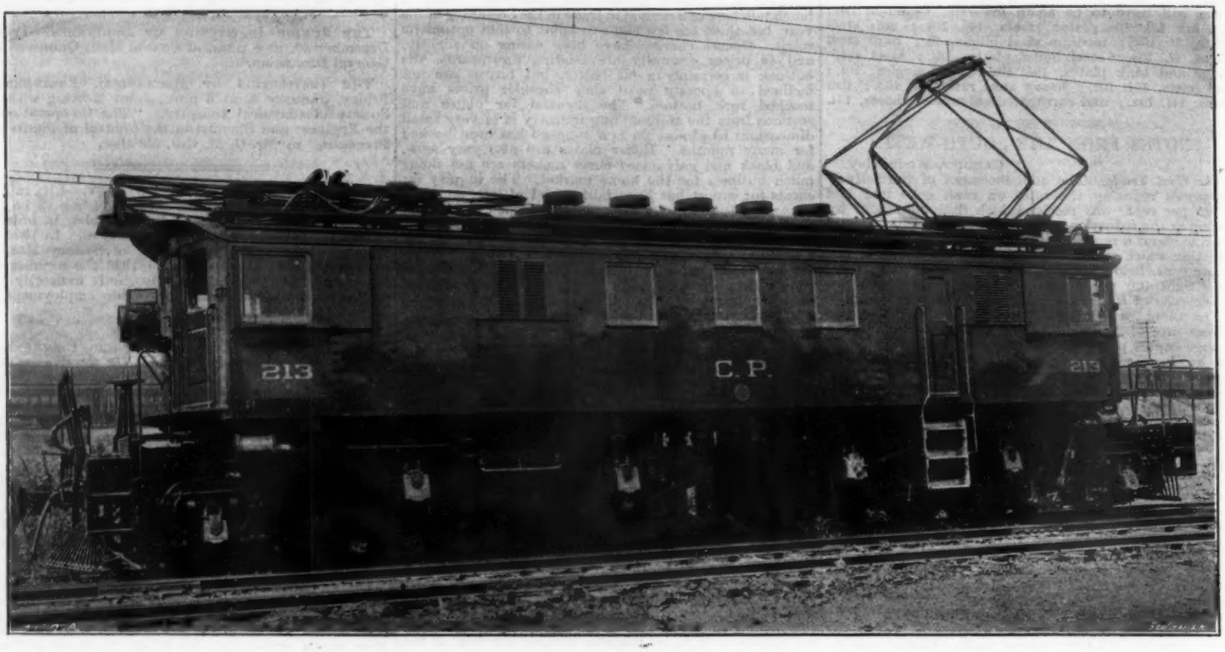


Fig. 1. 2-4-0 + 0-4-2 Type Passenger Locomotive.

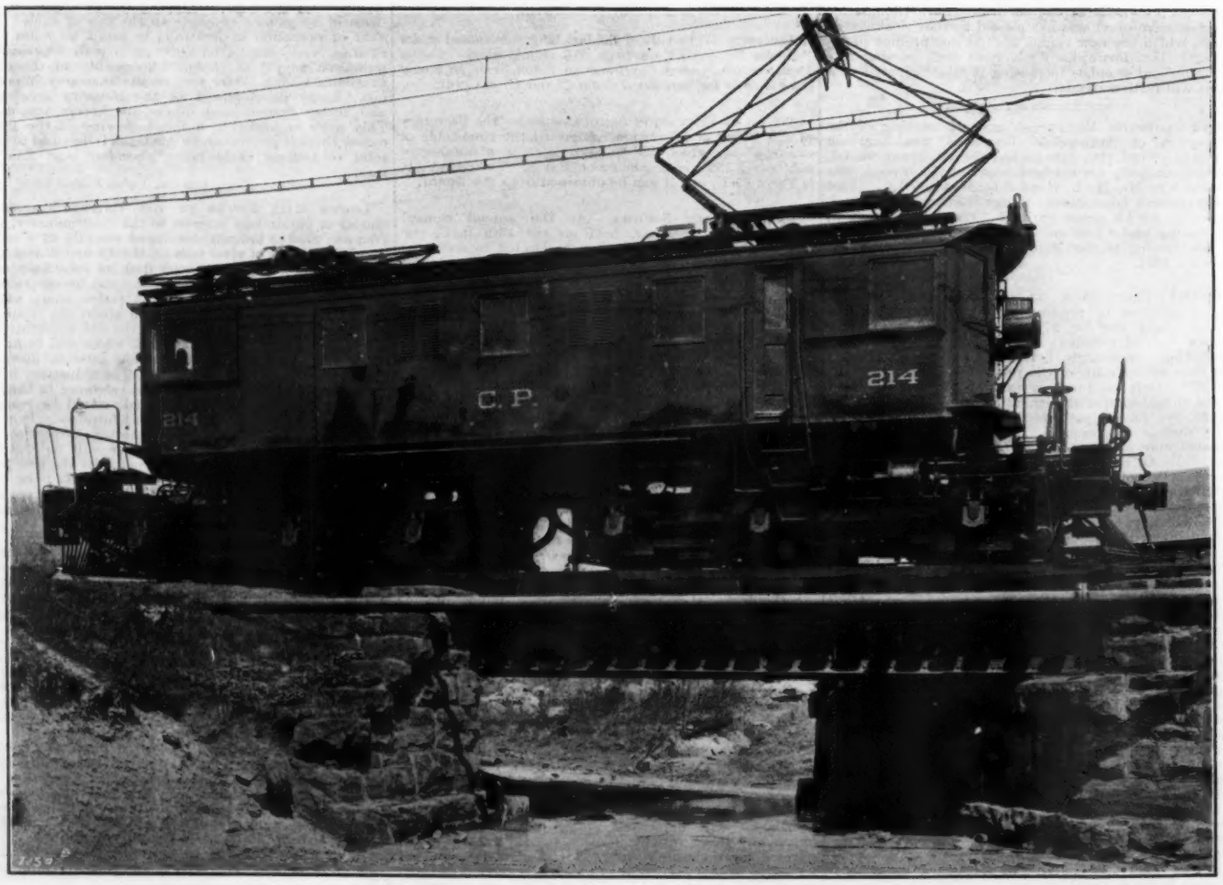


Fig. 2. 0-6-0 + 0-6-0 Type Goods Locomotive.

Fig.23. "A" DECK.

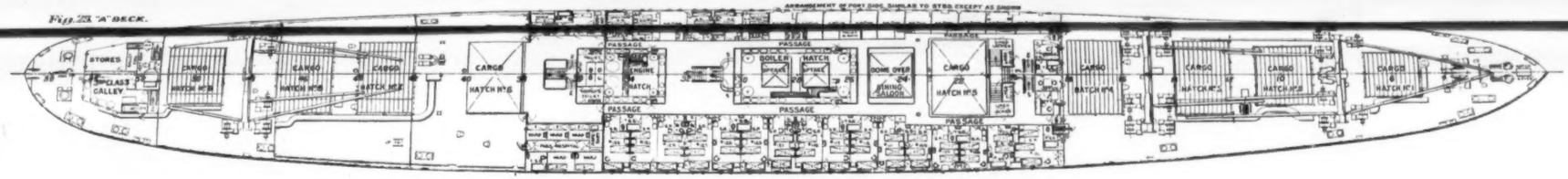


Fig.24. "B" DECK.

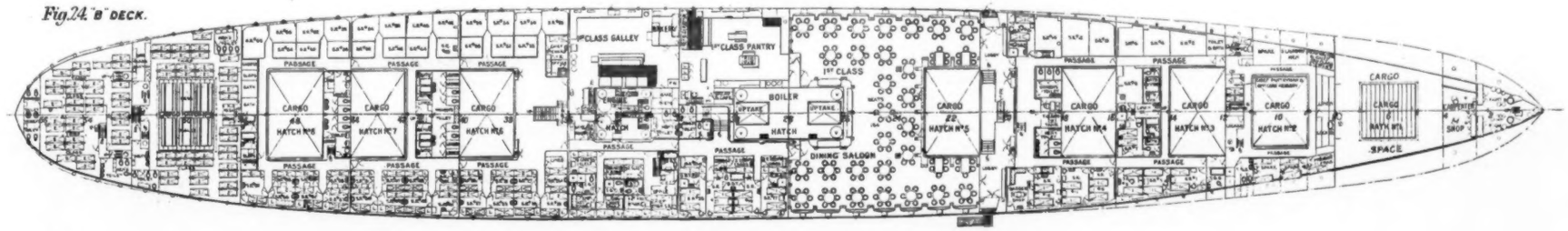


Fig.25. "C" DECK.

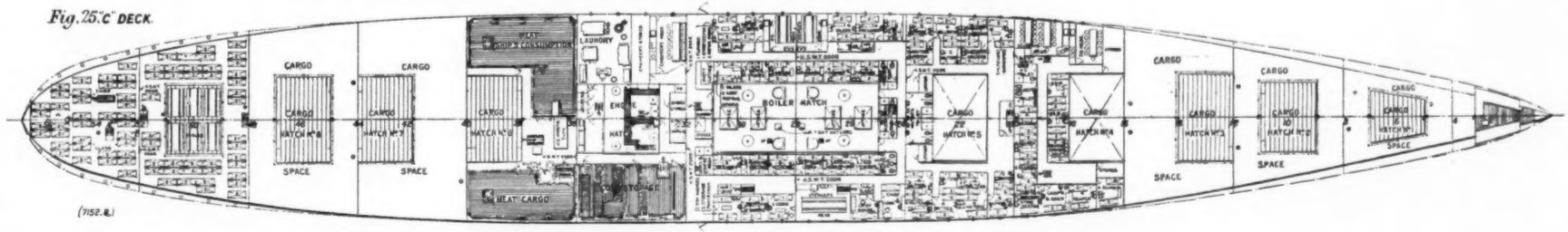


Fig.26. "B" DECK.

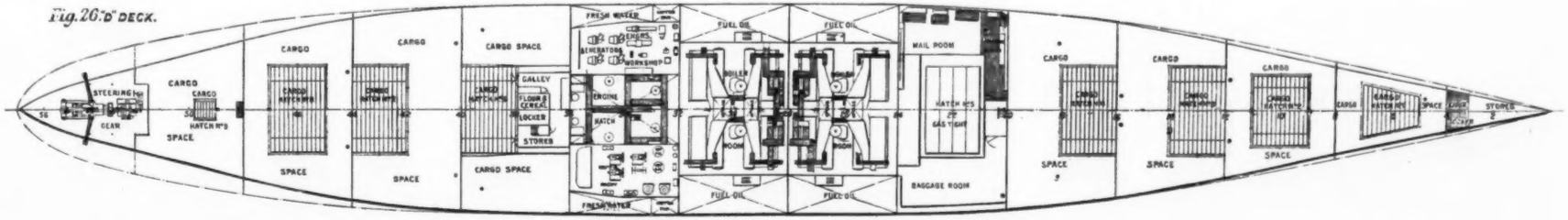
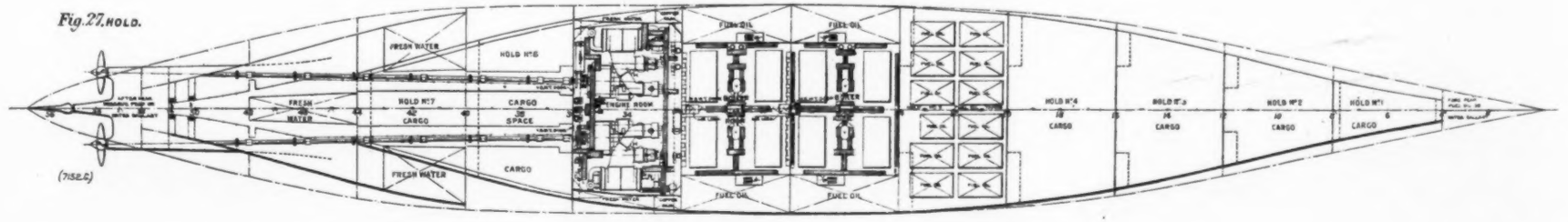


Fig.27. HOLD.



UNITED STATES PASSENGER STEAMER OF THE AMERICAN LEGION CLASS.

(*For Description, see Page* 847.)

Fig. 16.

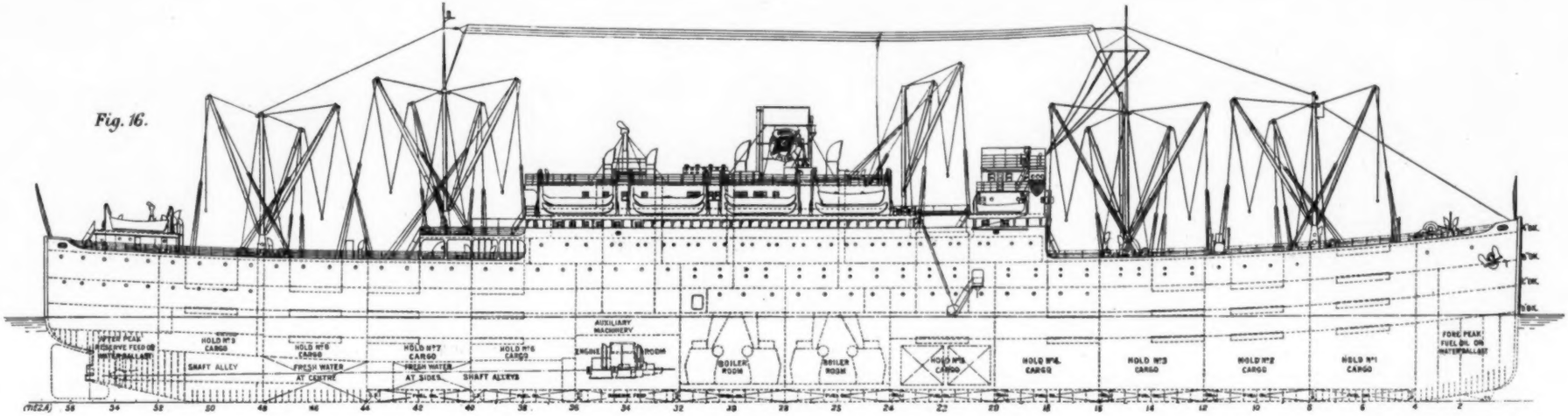


Fig. 17. HOUSE TOP.

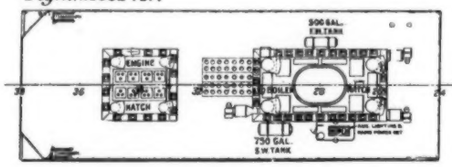


Fig. 18. BOAT DECK.

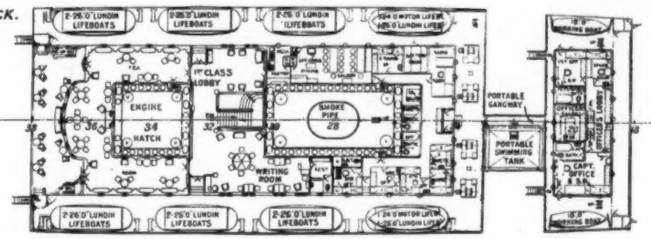


Fig. 19. NAVIGATING BRIDGE.

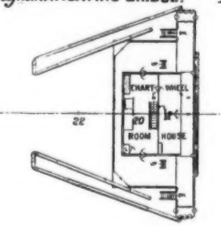


Fig. 20. FLYING BRIDGE.

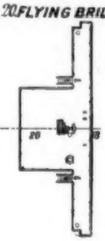


Fig. 21. HOUSE TOP.

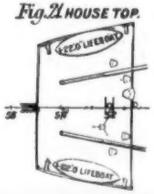


Fig. 22. BRIDGE DECK.

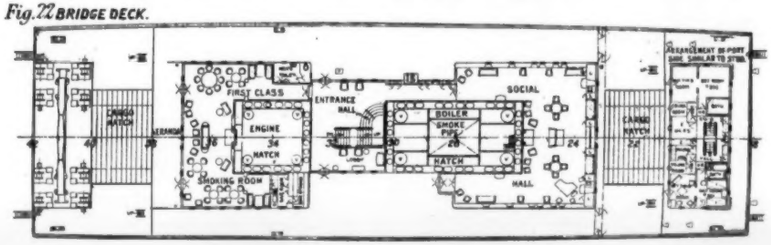
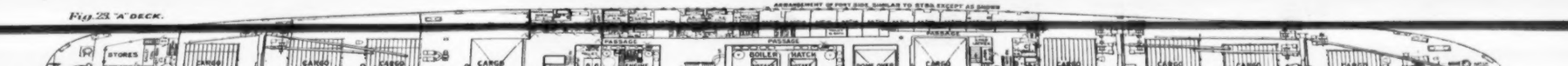


TABLE OF PASSENGERS & CREW

DECK	PASSENGERS				OFFICERS & CREW					
	FIRST CLASS		THIRD CLASS	TOTAL PASS.	DEPARTMENT			SPARE ROOMS		TOTAL CREW
	ROOMS	BERTHS			DECK	ENGINE	STEW'DS	ROOMS	BERTHS	
BOAT	—	—	—	—	10	—	—	1	1	11
BRIDGE	4	8	—	8	—	—	—	—	—	—
X	31	55	—	55	—	—	2	—	—	2
W	60	110	164	309	2	11	15	5	9	37
C	—	—	134	134	33	66	82	—	—	180
TOTALS	105	284	298	682	46	46	108	6	10	210

Fig. 23. "A" DECK.



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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 855.

ENGINEERING.

***FRIDAY, DECEMBER* 23, 1921.**

ELECTRICITY SUPPLY IN LONDON AND THE HOME COUNTIES.

LAST week saw what one earnestly hopes may prove a real step forward in the unification of electricity supply in Greater London. Since somewhere about 1905 effort after effort has been made by one party or another to introduce some sort of technical sanity into this important question, but scheme after scheme has proved abortive. As a rule administrative jealousy has been at the back of failure, and not the least practical importance of the report, or statement, issued by the Electricity Commissioners last week is that it is able to make recommendations with which the majority of the public and private bodies concerned are prepared to display some measure of agreement. The report has, as we understand it, been issued mainly for the information of the various bodies concerned. Officially it does not carry matters further, but it is of much value that the electrical industry should as soon as possible be made acquainted with the outcome of the Inquiry of last summer into the question of the formation of a Joint Authority for the district. In due course the Commissioners will draft an Order embodying their decisions and a further Inquiry will be held under the terms of the Electricity Act of 1919.

In its broad features the report may be said to accept the technical scheme put forward by the London County Council, the Conference of Local Authorities in Greater London and the London Joint Committee which represented a majority of the supply companies. The scheme briefly is for the immediate linking-up of certain existing generating stations so that present plant may be used to the best advantage. This procedure would in effect extend the generating capacity without any new machines being put down, since the total quantity of spare plant could be reduced. The interconnection would also be of value on the peak, since were a station in difficulty it would usually happen that other stations could relieve it to some extent. This would apply even if all peaks fell together. A certain amount of this interconnecting and mutual assistance is already in operation, it having been authorised by the London Electric Supply Acts of 1908 and 1910. Earlier than that such co-operation was illegal, a state of affairs which as it is now a thing of the past we may leave without comment. In connection with the linking-up proposals, a certain number of uneconomical and badly situated stations would be at once closed down.

Statistics show that the total demand in the district covered by the proposed Joint Authority was 320,600 kw. in 1919-1920, and it is estimated that by 1925-1926 the demand will reach 465,000 kw. and by 1930-1931, 660,200 kw. These figures do not include supplies to railways for traction purposes. The technical scheme involves the ultimate retaining of nine existing stations which are to be termed "group" stations and the gradual supersession of further existing stations. The group stations will be extended as needed, and the purchase of new generating plant for extensions to meet the first stage of the scheme has already been authorised by the Commissioners. With these extensions the total generating capacity will reach 633,000 kw. This figure, as we understand the report, appears to apply to the period ending 1925-1926, so that apparently a more than ample margin is to be in hand for handling a total demand of 465,000 kw.

The original scheme as put forward by the London County Council and the other bodies we have mentioned contemplated the installation of a further 199,000 kw. of plant in the group stations, bringing the total capacity up to 832,000 kw. about 1930. The estimated expenditure for this would be 9,750,000*l.*, which works out at about 49*l.* a kilowatt. As an alternative it was proposed that 645,000 kw. of plant should be installed in new riverside "capital" stations and the plant in "group" stations reduced by 324,400 kw. The report points out that this plant would have been thrown aside long before the end of its economic life, and states that this alternative would have involved new capital expenditure amounting to 23,855,000*l.* The report accepts neither of these schemes, and proposes that the 199,000 kw. of plant shall be installed in a new "capital" station or stations, the "group" stations being retained as developed during the first stage of the scheme. It is stated that "this will need practically no more new capital expenditure than the continued extension of the group stations." It is estimated that this scheme would make an annual saving of 1,000,000*l.* per year in the cost of electricity delivered.

There are not sufficient data available to discuss this question in detail, but the Commissioners' decision would appear a wise one. The figure for extending group stations as we have said works out at 49*l.* a kilowatt. In view of the type of work contemplated and present prices the figure is probably not excessive, but if the 9,750,000*l.* is spent on a new riverside station we imagine a good deal more value will be obtained for the money. As we have said, no details are available, but presumably a considerable part of the expenditure in the case of the extension scheme would go in necessary, but, from a productive point of view, useless alterations to existing buildings, purchase of land, modification of coaling plants, &c. Buildings, land and coaling plant are necessary parts of a generating station, but they cost relatively much less if forming part of a new capital station than if distributed in the form of extensions to existing stations which may be assumed to have reached the maximum capacity for which they were first laid out. The report apparently does not contemplate that any of the 9,750,000*l.* will be saved by installing the 199,000 kw. of plant in a new capital station, but one may presume the figure is to include main distribution from the station. If not, a figure less than 49*l.* a kilowatt should surely be possible even in 1921.

It is proposed that this unified generating system we have sketched should be administered by a Joint Authority which in composition would not greatly differ from that put forward by the London County Council at the Inquiry. Local authorities who are authorised undertakers would have eight representatives; company undertakers, eight representatives; the London County Council, six; other county councils, who would also represent urban and rural districts not owning undertakings, would have three members; and railway companies, one. The area covered by the Joint Authority would extend far into rural districts in which electricity supply is little, or not at all, developed. It would include Billericay in Essex, Sevenoaks in Kent, Guildford in Surrey, Beaconsfield in Buckinghamshire, and would extend well north of Hertford in Hertfordshire. It is fairly clear that a composite and necessarily somewhat slow-moving body of the kind proposed would not necessarily be the most likely authority to develop electricity supply in some of the outer districts in the area, and this would appear to have been realised by the Commissioners, since it is not proposed to interfere with the rights of the North Metropolitan Electric Power Supply Company, or the bulk supply rights of the Metropolitan Electric Power Supply Company. No arrangements leaving private enterprise a freer hand are made in connection with southern parts of the area, but when the Joint Authority is constituted there is nothing to prevent it entering into arrangements of this kind.

It will be clearly understood that the arrangements for the constitution and operation of the Joint Authority are not yet in being, and as always in connection with this subject the greatest difficulty will be met in perfecting a scheme which all the parties concerned will be prepared to come into. The intention is that the group stations shall be vested in the Joint Authority and that the present distributors shall remain distributors. As matters

now stand the supply companies are in the position that they may be bought out in 1931. This condition has for many years tended to throttle electricity supply in London. A company which may be bought out in a few years, and which is far from sure that it will be bought out on a basis which it considers just, is not likely to commit itself to much capital expenditure for development work. The right of purchase which originally belonged to the local authority is now vested in the London County Council. As part of the proposed settlement the London County Council is prepared to transfer these powers to the Joint Authority, while the report states that the Associated Companies are prepared to vest their stations in the Joint Authority under a deferred payment arrangement subject to an extension of tenure as distributors. The number of years over which this extension would spread is, however, not stated.

In connection with the money side of the scheme it will probably be remembered that the Electricity Act of 1919 contains no provisions for the financing of Joint Authorities. The financial provisions were cut out of the original Bill in its passage through Parliament, and one or two half-hearted attempts which have been made to pass a special financial Bill have been abortive. The Government's record in this matter does it no credit. The consequence is that as matters stand at present the Joint Authority will possess no borrowing powers. According to the report it is proposed to meet this condition by means of a sum of 1,200,000*l.* which it is stated the Associated Companies are prepared to advance, while the London County Council and the Conference of Local Authorities have agreed to assist with their municipal credit. This 1,200,000*l.* appears a very important link in the chain which is to set the Joint Authority in motion.

As we read the report the Electricity Commissioners do not doubt that this 1,200,000*l.* will be forthcoming, but that there is a misunderstanding somewhere is shown by the letter from the chairman of the Joint Committee of Companies, which appeared in *The Times* of Saturday last. The letter stated that the financial proposals of the companies were contingent on the financial control of the Joint Authorities' work remaining in the hands of members representing the body which provided the funds. It is difficult to see how any effective working authority could be constituted if the whole of the financial control of the bodies' activities were to centre in a minority. On the other hand, it would appear natural that the companies should wish to maintain control of their own funds. The whole situation suggests a deadlock, but there is yet much time for further discussion and more proposals. We shall without doubt have reason to refer to the subject again later. A final reference should be made to the proposed capital station. The County of London Electric Supply Company already has powers to build a 100,000 kw. station at Barking. They may, however, only proceed subject to the consent of the Commissioners. The report states that the company is prepared to begin construction immediately, but since by the terms of their Act they may be called upon at any time before August, 1926, to sell this station to the Joint Authority on terms to be prescribed by the Commissioners, it would not appear *primâ facie* likely that the company will build without some understanding about the detail operation of this purchase clause.

THE REDUCTION OF NAVAL ARMAMENTS.

An agreement had been reached between the three chief naval powers, Great Britain, the United States and Japan, with regard to the proposals for the limitation of naval armaments forwarded by the United States Government at the Washington Conference, in so far as these relate to capital ships for the next few years. It will be remembered that these proposals, which were outlined on page 704 *ante*, involved the abandonment or scrapping of a number of capital ships either commenced or contemplated, as well as the destruction of a large number of older vessels. It was also suggested that no replacement tonnage should be laid down for a period of ten years, and that the maximum tonnage of future capital ships should be limited to 35,000. On a tonnage basis, the relative naval strengths of the three countries above referred to were to be in the ratio 5 : 5 : 3, respectively.

The proposals were immediately accepted in principle by each of the three countries named, but certain modifications were made before final agreement in order to comply with the Japanese desire to retain the battleship Mutsu, which was to have been scrapped. The Mutsu, which was launched in May of last year, has a displacement tonnage of 33,800, and is provided with machinery developing 46,000 h.p.; her main armament consists of eight 16-in. guns. Japan agreed to scrap the battleship Settsu, of 20,800 tons, completed in 1912, which was left to her by the original United States proposals, so that although the number of capital ships remaining in the Japanese Navy will not be altered, the tonnage will be increased by 13,000, and the efficiency of the fleet will be materially improved by the inclusion of the more modern vessel. The retention of the Mutsu, together with the Nagato, will thus give Japan two capital ships of post-Jutland design. The capital ships of the Japanese Navy will now include 6 battleships making 191,320 tons and 4 battle cruisers of 110,000 tons together, the total tonnage being 301,320 instead of 288,320. as given in Table II, on page 704 *ante*. In this connection we would again remark that we have taken the tonnage figures now quoted from an Admiralty White Paper prepared in February last, and these figures are not in complete accordance with those published in Washington.

To preserve the pre-determined ratio of strength between the three powers, the final agreement allows for the completion by the United States of the battleships Washington and Colorado, of 32,600 tons each, and for the scrapping of the battleships Delaware and North Dakota, of 20,000 tons each which were completed in 1909. This modification thus adds 25,200 tons to the total tonnage of the 18 capital ships of the American Navy, the figure now being 525,450 tons, as compared with 500,250 tons given in our previous article. America will now have three post-Jutland ships of the "Colorado" class, viz., Maryland, Washington and Colorado, each mounting eight 16-in. guns, in addition to the three ships of the "New Mexico" class launched in 1917, and the Tennessee and California, both launched in 1919. The main armament of the five vessels last mentioned consists of twelve 14-in. guns in each case.

As mentioned on page 704 *ante*, the original proposals would have left this country without any capital ship mounting 16-in. guns or including in its design the whole of the experience gained as a result of the Jutland action. Our latest ship, the Hood, as is well known, was designed prior to that engagement, and although certain alterations were made subsequently, it cannot be regarded as a post-Jutland ship. To equalise the position it has therefore been agreed that Great Britain shall construct two new ships of a tonnage not exceeding 35,000 each, and when these are completed, the old battleships Erin (formerly the Reshadieh), Ajax, Centurion and King George V, are to be scrapped. These four ships, which were completed between 1912 and 1914, are each of 23,000 tons, and each carries ten 13·5-in. guns. This alteration will thus reduce the number of capital ships in the British Navy from 22 to 20 and the aggregate tonnage from 580,950 to 558,950. The tonnage, it will be noted, exceeds that of the United States by 33,500, but this is thought to be reasonable on account of the age of the British battleships of the "Royal Sovereign" and "Queen Elizabeth" classes. Each of these classes includes five ships, each mounting eight 15-in. guns. The ships of the "Queen Elizabeth" class were completed in 1915 and 1916, while those of the "Royal Sovereign" class were all completed in 1916, except the Ramillies, which was finished in the following year.

Chief interest now centres in the design of the two new ships, but it will be obvious that these must differ materially from the new Hoods, the building of which had been postponed, since the tonnage allowance is only 35,000; the tonnage of the existing Hood, it will be remembered, is 41,200. The armament of the new vessels will presumably be at least equal to that of the post-Jutland ships of the American and Japanese Navies, but it will be extremely interesting to see how our designers will divide the remaining weight between hull protection, ammunition, machinery and fuel supply. The result is likely to have considerable influence on naval design of the future, since 35,000 tons is the maximum displacement allowed by the terms of the agreement for the replacement vessels which may be built after ten years by any of the powers when their ships become twenty years old. Disappointment will, of course, be felt in many quarters that the new Hoods will not now be proceeded with, so that the work involved in the preparation of the designs and tenders for these ships will apparently be fruitless. A more serious aspect of the situation created as a result of the Conference agreement is, however, that since some considerable time must elapse before work on the two new ships can be commenced, the partial solution which the construction of the new Hoods would have provided to the pressing problem of unemployment will not now be available.

In connection with replacements it should be mentioned that the limit for the aggregate tonnage of capital ships for the future British and American navies has been raised from 500,000 to 525,000, and that for the Japanese Navy from 300,000 to 315,000. These tonnages are, however, based on American calculations which give rather higher figures than British methods do. As an example of this difference we may point out that the maximum tonnage of the replacement ships, given above as 35,000, would be 37,000 if calculated according to American standards.

As regards capital ships, the tonnage ratios fixed by the original United States proposals for France and Italy were 1·75 in both cases, as compared with 5 each for Great Britain and the United States and 3 for Japan. Both France and Italy, it is understood, have now officially accepted the ratios proposed. The question of the number and tonnage of auxiliary craft such as cruisers, aircraft carriers, destroyers, submarines, &c., to be allotted to the various powers is however, still under consideration. But little information as to the exact nature of the proposals made with regard to these vessels has yet been published, so that they cannot be discussed in detail. We wish, however, again to call attention to this country's special need for a large number of vessels of the light-cruiser class for the protection of its commerce and its widely scattered possessions and sea communications. Our requirements in this respect are obviously much greater than those of either the United States or Japan, so that the ratio accepted in the case of capital ships could not properly be applied to vessels of the light-cruiser class. It would appear to be essential to build a considerable number of these vessels within the next few years to replace those which are now rapidly becoming obsolescent. The British suggestion regarding submarines is that the use of this type of craft should be completely abandoned, but it seems improbable that this suggestion will be found generally acceptable. France particularly, regards the submarine as an essential weapon of defence, and it is also regarded in a favourable light by most of the lesser naval powers. Generally, it may be remarked, the work of the Conference appears to be progressing smoothly and favourably, such differences of opinion as have so far arisen having been adjusted in a spirit which augurs well for the success of the future proceedings.

RAILWAY ELECTRIFICATION.

It is one of the handicaps of electric traction that to be tried at all it has to be instituted on a large scale. If it were possible to convert gradually, as a shipping company might, by putting one vessel of a new type into commission at a time, or even feasible as in the case of the motor 'bus or char-à-banc services to make a trial, and if not successful to divert the stock elsewhere, we might see more endeavour made to try out this form of haulage which undoubtedly presents attractions. In this respect the electric operation of our main lines of railway is sadly handicapped. To form a fair guide any experiment has to be tried on a

scale which involves heavy capital expenditure, which in these days is difficult to arrange for satisfactorily, while the risk of a comparative, if not actual, failure has to be carefully avoided. We use the term failure here not as in any sense implying mechanical or electrical breakdown, or even financial ruin, but it is clear that if to their present capital, railways are to add the capital required for electrification, the improvement in operation must suffice to furnish a return covering the whole. Equally good overall results would not be good enough, unless for certain reasons, other than commercial conditions are introduced, as was the case in the original electrification of the New York Central terminal section.

It is this wider aspect of electrification which really presents the difficulty. If a return, say of 4 per cent., is now paid on railway capital, of what value will electrification be unless something over this be possible on the enlarged capital investment. This margin, too, must be large enough for the promoters to be able confidently to put forward conversion proposals on the score of certain, or at least most probable, benefit, and not only on the strength of possible advantage.

It may be taken for granted nowadays that, provided this aspect be assured, no one will be found to contest the operating advantages of the electric locomotive. Apart from the risk that electrification, in the event of a breakdown, involves temporarily tying up a whole section of a system, and not just one train unit, and apart from possible defects in type or detail design of the locomotives themselves, which time and experience will doubtless remedy, the improvement in operation made possible with electric traction is hardly questionable. These points have been often stated, and there has now been sufficient experience to prove that they are not as imaginary as some of the gains which were promised by enthusiasts years ago.

The case from the operating point of view has been several times stated, but not often in this country with the weight of experience Sir Vincent L. Raven, K.B.E., was able to put into a paper on "Railway Electrification," read by him on the 16th inst., before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle. On previous occasions we have had accounts of the electrification of parts of the Lancashire and Yorkshire Railway, the Midland, and the London, Brighton and South Coast. These have rather taken the form of descriptions of the engineering features, and the results, of the conversion of somewhat special traffic to electrical working. Sir Vincent's recent paper, which we hope to reprint in an early issue, was concerned more with the locomotive man's view of electric locomotive operation as compared with steam engine working, and the effect of such a change on traffic.

In these days when the costs of new work are so high, the need of a sound case from a financial point of view is even greater than before the war. It may be that the proposals with regard to reparation in kind may lead to Germany supplying us with electrification material, when railways would perhaps secure plant on rather more advatageous terms than they could otherwise do. But if such reparation is to be of national value the cost to the railway must have a reasonable relation to the real value of the plant so that the Treasury may benefit to a due extent, and not mainly a particular railway company. On the other hand, as we have lately frequently pointed out, the railways are now faced with an entirely new problem in this country. Working expenses have risen to so high a level due to the cost of labour, that any system which can offer reduction of labour in operation, and the subsidiary services of attention and repairs, as well as reduction in coal consumption and coal haulage, merits consideration nowadays from a standpoint quite different from that from which such matters were before regarded.

There is, unfortunately, no possibility here of schemes of electrification such as that carried out on the Chicago, Milwaukee and St. Paul Railroad, where power is cheaply produced by hydro-electric stations, and the grades are long enough for regenerative braking to have an appreciable effect on the supply. We are not so favourably placed, but even so Sir Vincent's facts regarding the North Eastern services are most interesting. The decisive factor, however, at the moment, if we accept as proven the advantages on the operating side, is whether the service can stand additional capital charges at the present high level. Had it been possible for the capital cost to remain at something like pre-war level, in spite of the higher charges for labour, coal, &c., we may take it that the present greater incidence of the latter would probably in itself have justified the change.

The North Eastern Railway is building a high-speed passenger locomotive, which will be the first of its kind in this country. In view of the fact that this company is likely to form part of the larger North Eastern group, and that the latest electrification on this railway practically conforms with the recommended standards suggested by the Advisory Committee on Electrification to the Ministry of Transport, the performance of this locomotive will be watched with great interest, and the results obtained will be much more valuable than any amount of figures from other countries. We have now had experience here with suburban traffic and mineral traffic, and high-speed passenger trials would considerably extend our range of first-hand knowledge of electric railway working.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A MEETING of the above Institution was held on the 16th inst., at the Institution Building, Westminster, the chair being occupied by the president, Captain H. Riall Sankey.

ROYAL CHARTER.

Opening the proceedings, the president said that the council, in consequence of other institutions petitioning for a Royal Charter, had considered the advisability of the Institution taking the like step. After investigation, however, it was decided not to recommend any departure from the existing constitution; the Memorandum of Association enabled members to regulate their own affairs and alter articles and by-laws from time to time without having to apply to any outside authority for approval. The council's investigation, however, disclosed certain anomalies at present existing, and improvements having been suggested, the council had prepared alterations which would be submitted to the members in January next, and would be published in the "Journal" for that month.

The proposals affected new grades of membership, the qualification of members, and the adoption of the name "corporate member." It would surprise many associate members to learn that, under the Articles, they were not "members"; this the council desired to correct. Other points included the question whether associate members should be eligible as members of council. The president reminded members that this question had been raised some two years ago, and the poll then taken was in favour. Accordingly a by-law had been framed to that effect.

The Articles would be considered at a special meeting on January 20 next, for approval or otherwise. A confirmatory meeting would be held on February 17 next, at which there would be no discussion, the meeting merely being asked to decide whether or not the Articles adopted in January should be agreed to. At the commencement of the ordinary general meeting (following the special meeting), he would give notice of the proposals previously circulated and amendments (if any). He desired that members should, when the "Journal" was issued on January 6 next, take all the points raised into careful consideration.

CONVEYORS AND ELEVATORS.

The first paper down for reading and discussion was one entitled "Conveying and Elevating Machinery." It was read by its author, Mr. Gardiner Mitchell, of Aberdeen. We print this paper in full in another part of the present issue, and need not reproduce Mr. Mitchell's introductory summary.

The second paper was one entitled "Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators," by R. E. Knight, of London. This paper we also print in full in another part of this issue. During his summary of the paper Mr. Knight pointed out that in the figures illustrating the Dolphin grain elevator at Millwall Docks, three suction pipes were shown; actually, however, as stated in the table, there were only two. Mr. Knight also referred to Table III. He wished to point out that the table was concerned with working tests only, and that they were not taken under the best possible conditions. The tonnage was a bit low, but the delivery conditions had a good deal of effect on the actual tonnage discharge. The machines had been tested under better conditions and had lifted as much as 120 tons an hour. Mr. Knight went on to say that he had had tests taken in November and December of this year to confirm the figures given in the table. With all classes of grain and with runs of from 4½ hours to 6½ hours, and with a length of pipe line of 70 ft., the results obtained ranged from 1·1 b.h.p. to 1·35 b.h.p. per ton per hour.

Mr. C. R. S. Kirkpatrick opened the discussion. He said that in the Port of London, with which he was connected, conveying plant could be used for discharging almost every class of goods. An important problem which Mr. Mitchell had not touched upon, however, was the mechanical conveying and sorting of timber. During the years he had been at the port he had found no one who had succeeded in solving that very real difficulty. At present when a ship full of deals was unloaded by derricks on to the quay, the sorting of the timber, with its multifarious marks and signs, had to be done by hand. Turning to Mr. Knight's paper, Mr. Kirkpatrick referred to the late Mr. Duckham as the pioneer of the pneumatic process of grain discharge, and said it was not without some feeling that during the last eighteen months he had had to pull to pieces work which Mr. Duckham had carried out. The Millwall installation originally consisted of a very heavy horizontal reciprocating steam engine, for the air exhausters, since replaced by turbo-exhausters. The old plant took up 60,000 cub. ft., while the electrical plant with the turbo-exhausters only required 22,000 cub. ft. Again, the weight of the steam machinery was 160 tons, whereas that of the electrical machinery was 50 tons.

The late Mr. A. H. Mitchell was, he considered, second only to Mr. Duckham in pioneer work with the pneumatic process. About 1913, he and Mr. Mitchell were commissioned by the port authority to go and ascertain what was being done in Europe. He had an interesting discussion with the manager of the Hamburg grain elevator plant, who warned him that turbo-exhausters had been tried at Hamburg but had failed. Nevertheless, Mr. Mitchell and he tried them at the Port of London. Perhaps the most interesting item they saw was the plant at Genoa. The exhausters were of the vertical reciprocating type, and there was a fixed jetty running out from the warehouse for two or three ship lengths, and carrying fixed pneumatic pipes which could be placed in the holds of ships. The pipes were connected to a long horizontal pipe. With 1,800 h.p. of machinery the plant only moved 450 tons per hour. The reason was the long horizontal drag. Having got the grain on to the quay it was necessary to drag it as far as 1,500 ft. along the horizontal pipes to the warehouse.

The problem of grain discharge in London was a more difficult one than in German ports, or at Antwerp and Rotterdam. At these ports the whole ship was discharged into barges up to 3,500 tons capacity. In the case of London, however, the grain arrived in small parcels and had to be dealt with in small barges; continual change of barges being necessary. In conclusion, Mr. Kirkpatrick referred to the fact that, in seeking tenders for two elevators which the Port Authority proposed to purchase, he had left open the question whether reciprocating or turbo-exhausters should be used. The gears of turbo-exhausters presented difficulties yet to be surmounted. If direct drive could be secured, and gears done away with, the problem would be solved. That was his reason for seeking tenders both ways, and asking for the data on which such tenders would be based.

Mr. Claude Scrutton said that in handling general

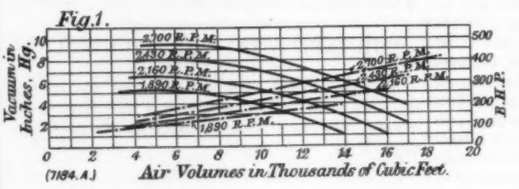
cargoes in the Port of London we had not greatly advanced on the methods of thirty years ago, although in the discharge of grain there was a great difference of method. One factor which affected the possibility of improving elevators and conveyors for discharging cargo was that the whole operation had to be synchronised to the point of final delivery. The present method involved the crane, or derrick, for the discharge to the quay, and then the hand truck to the sheds. Year by year the crane and the derrick had become less efficient, on account of larger and higher vessels, and the output gradually dwindled. Experiments had been made by his firm in bringing belting up to the ship's hatch, and in this case the net result in output was something approaching the proportion of 3 : 1 for the derrick or crane. It was, however, difficult to continue experiments which had to be carried out in a more or less disjointed fashion; and the problem had to be thought out as a whole. No physical difficulty existed, and when it was possible to put in the necessary gear the results were quite surprising.

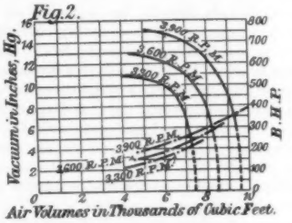
His firm had, further, made experiments in dealing with box cargoes, and in that connection elevators were suitable and easy to use. An important point was the question of stacking on the quays. A visit to the sheds of a London dock would show boxes packed 15 ft. high by hand, and he felt that the time was ripe for the erection of special warehouses. An inclined runway should be used to stack the boxes so that they simply formed their own bank, requiring no manual labour.

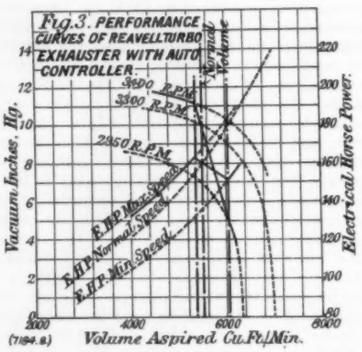
Brigadier-General Mowat was interested in the comparative merits of the ordinary bucket elevator and the pneumatic elevator. To determine these merits, consideration must be given to the character of the cargoes and the conditions of the ports in which they were used. The ordinary bucket elevator would prove most economical for ports in the West of England, dealing with American cargoes, and where the practice was to grade the grain and store it in huge silos and large granaries. In London conditions were different. Before the advent of the Port of London Authority there were three large dock companies contending with each other, and a ship coming into the port was met at Gravesend by rival representatives of these companies, and it became a question of inducing the ship to come in. There was no idea of putting down plant that would discharge at a tremendous rate; merchants, indeed, openly said that the longer they took in unloading freights the better for them. The grain coming into London came chiefly from the Baltic or the Black Sea, and was made up in comparatively small parcels divided by matting. He had seen cargoes that had no less then 60 or 70 different divisions. It was impossible to work a bucket elevator with cargoes of that description; the only alternative to the old method of bushelling was the use of the pneumatic system.

He would like to refer to the dominant considerations at the time when the Millwall plant was designed, in 1902. In the newly-created Borough of Poplar the supply of electric current was neither abundant nor cheap, which affected the use of electric motors. The question of reduction gear was then much to the fore, and accordingly various schemes were got out for working electric motors in conjunction with reciprocating pumps. Reliable gear could not, however, be obtained, and it was necessary to revert to the steam engines which, in former instances, had proved effective. Mr. Knight had alluded to the reversion to the use of the automatic weighing machine. He recalled the installation of an Avery automatic weighing machine, which led to contention between shipper and merchant as to results: it became necessary to remove the machine because it weighed accurately! It was contended that by weighing into sacks by hand machines there would be a gain of 2*l.* to 5*l.* for every ton of grain in draftage. Now, however, that the Port Authority possessed complete control, appliances of the type rejected were being re-installed. With regard to timber, he would say that a timber transporter had been used at Millwall which picked up the deals from the barges, and sent them up an elevator on hooks, when they passed into a trough at the top, running on cast-iron roller wheels. The deals had to be taken to their destination over a railway into a field. The apparatus did not, however, sort the deals, and it was complained that the transporter did not pay because of cost in labour for sorting, and that what was wanted was a device which would sort mechanically. The transporter, however, did the conveying very well. It was made by Bolinders, of Stockholm.

Mr. H. J. Deane, of the Port of London Authority, said that the port had acquired considerable experience with turbo-exhausters, but, so far as he knew, no one in this country had done any experimental work with large parcels, and the machines possessed by the port were the only ones at present at work. Two were put up largely as a matter of experiment. Since that date a good deal of development had taken place, and the characteristics of the exhausters now being built differed from those of the first two "turbos" constructed. Much was being learnt, particularly by the makers of the exhausters. He was satisfied that, subject to certain provisos, the turbo-exhauster was the machine required. The provisos were that some







appropriate mechanism should be introduced either to maintain a constant vacuum and constant flow of air, or to prevent the quantity of air increasing beyond a predetermined amount.

To illustrate his point Mr. Deane exhibited the diagrams which we reproduce in Figs. 1 and 2. Fig. 1 referred to the earlier exhausters and Fig. 2 to the later. The full line upper curves in these diagrams represented brake horse-power, and the lower chain-dotted curves represented vacuum. If a point on the top curve of all in Fig. 1 were considered corresponding to an air delivery of 8,000 cub. ft., and a vacuum of 9 in., it would be seen that (reading from the uppermost of the lower set of curves in the same figure) this would require just over 200 h.p. If, then, one considered the vacuum broken down for some reason, the brake horse-power reading would travel up the curve shown and one would reach a point where the brake horse-power was just under 400, so that there would be an overload of 100 per cent., and yet the vacuum would have fallen to below 4 in. and the quantity gone up to something like 17,000 cub. ft. On the other hand, in the machine represented by Fig. 2 the characteristics were such that should the vacuum drop, the quantity of air would not increase in the same proportion and the brake horse-power would not go up beyond a certain predetermined amount. That was a very excellent machine, and the designer was to be sincerely congratulated.

The next thing to do was to put an effective air control into the pipe line, so that once it was predetermined what vacuum was required and what quantity of air—no matter whether the pipes were in the grain or out of it—constant volume and constant vacuum would be retained. On the subject of the output of the machines per brake horse-power per ton of grain, he would remark that if any one interested would refer to Professor Cramp's paper he would reach the conclusion that the machines under discussion absorbed approximately four times as much power as they should do according to Professor Cramp's theoretical results. Certainly a vast amount of power was expended, but so far as the mechanical efficiency was concerned he did not regard this expenditure of power as of great account. It did, however, make a difference in the size of the plant. Taking the turbos 1 and 2, theoretically they should handle something like 220 tons to 250 tons per hour. The maximum amount ever handled by either of the machines was given by Mr. Knight as 120 tons, while certain figures obtained by him would increase the amount to 130 tons; that was far short of theoretical efficiency. The next step needed was to increase efficiency so that if it were not desired to get up to 250 tons per hour, but to remain at something like 100 tons as a maximum, it would be possible to reduce the size of the plant and at the same time, of course, the cost of running.

Mr. C. R. Kininmonth referred to the work of the late Mr. A. H. Mitchell, and supported earlier speakers in attributing to his genius and judgment the modern developments in pneumatic grain-handling plant. Mr. Mitchell's work, moreover, was typically British, and comparison of recent developments with contemporaneous developments in Germany was interesting. To the late Mr. Duckham's type "A" machine the Germans applied their thermodynamical knowledge to improve the efficiency, and they produced more efficient vacuum pumps; yet in all essentials the machine remained as it was; the Germans applied knowledge, but little constructive or critical imagination, such as Mr. Mitchell used. The point about the pneumatic plant was its maintenance of capacity from start to finish, and Mr. Mitchell, recognising the efficacy of the plant, set about improvements, such as the application of electricity, and the oil engine. The speaker's firm had put to work on the Shannon, a vessel embodying some of these ideas. The vessel was a sea-going elevator with a beam limited to 25 ft., as against the 35 ft. of the ordinary German elevators; the capacity was 200 tons. The pipe handling gear was of Mitchell design, electrically controlled, and consisted, briefly, of a cantilever support. That vessel had crossed the Atlantic with everything fully rigged, and instead of being, like the German machines, 70 ft. or 80 ft. high, it could pass under the yards of a sailing ship. It could work on either side of the vessel and could get into or out of the largest ship bringing grain to the port of Limerick.

Mr. William Reavell said his firm were the makers of the machine having the characteristics shown by Fig. 2. Turning to Table I, Mr. Knight had explained that in the case of the Dolphins at Millwall the horse-power of the motors was 200. The reason for that was that the motors were so constructed as to be able to work up to 15 in. of vacuum, although the normal working was 11 in. With 11 in. of vacuum the electrical input to the machine was 175 h.p., while the brake horse-power of the motors was 155 or 156, when running at 6,000 cub. ft. per minute on shop tests. Much, of course, could be said for reciprocating machines as well as for turbine machines. It could readily be seen that the reciprocating machine, which necessarily had suction and delivery valves, could not always be sure of

getting clean air. The turbine machine had the advantage that there were no valves. On the other hand the turbine machine could not be made of small enough capacity—due regard being had to efficiency—to deal with some plants, and there was no question that the reciprocating machine had its field, unless some new form of rotary which was lighter and of higher speed could take its place.

Mr. Kirkpatrick had regarded the gears as the weak spot in the turbo machine, but it was not always necessary to use gears. In this country native-built high-speed motors of reasonable power for continuous current were difficult to obtain, and therefore where continuous current was used as the prime mover some form of gear must be introduced. Doubtless Mr. Kirkpatrick had in mind the difficulty of driving a purely rotary form of machine like the turbo-exhauster at high speed, through gears, from a two-stroke cycle oil engine. Of course, if the turbine could be driven from the power station with polyphase current, a two-pole high-speed motor could be used and the gear problem be done away with. But even if a continuous current motor be used, and the motor speed were insufficient, the gear troubles would not be so problematic as the effort to drive by reciprocating engines.

A reciprocating exhauster had the advantage that when the nozzle was pulled out of the grain the load upon the motor driving the reciprocating positive piston displacement machine was at once lightened; with a turbine, on the other hand, the withdrawal of the nozzle at once overloaded the turbine, as Mr. Deane showed in the diagram he exhibited. Some form of control to prevent overload was therefore necessary. A form of control embodied in a plant built by Mr. Reavell's firm was illustrated by the diagram given in Fig. 3. As would be seen, the type of characteristic was similar to that of Mr. Deane's Fig. 2. The top curve showed the volume pressure curve at maximum speed; the middle curve, the volume-pressure at normal speed; the bottom one the volume-pressure curve at slow speed. The motor was arranged with rheostatic control giving a total range of control of 15 per cent.; hence the three different speeds. By the special arrangement of the rheostatic control, instead of the overload being thrown upon the prime mover when the nozzle was pulled out of the grain, the speed was reduced automatically, and the variations in horse-power and volume followed the full lines which could be seen joining the dotted curves in Fig. 3. Nothing more than the normal horse-power was ever thrown upon the motor. As this was done with a control of only 15 per cent., it would readily be seen that if the motor was built for a control of greater range a still greater reduction in power could be automatically obtained.

For the automatic control a nozzle was inserted in the air pipe and Pitot tubes were connected on each side of it. There was a difference in pressure between these two tubes, depending on the velocity of flow. When the nose was pulled out of the grain the velocity of flow increased, and one got a great difference of pressure on one side and/or the other. That difference of pressure was used to operate directly the rheostatic control, so that as the difference in pressure increases the speed was reduced. This form of control could be quite readily used also to operate a balanced throttle valve.

Mr. Reavell went on to say that something on the lines of this balanced throttle valve was likely to come into use for turbo-exhausters, as the arrangement could be used with a constant-speed prime mover.

Mr. Mitchell then replied very briefly to the discussion. He observed that little had been said on the general type of elevator or conveyor, which for some work had to give place to pneumatic handling. There were, however, one or two things that pneumatic handling could not do. With regard to timber conveying, the point raised by Mr. Kirkpatrick had been effectively answered by General Mowat. Timber could be handled by ship elevators, running along troughs in which there might be endless ropes having drags attached to them. Mr. Scrutton had referred to general cargo, and, in this connection, he (the speaker) was aware of several installations dealing with a general cargo by elevators and conveyors.

At this point Mr. W. H. Atherton, of Derby, who had come to the meeting specially for the purpose, secured the permission of Dr. H. S. Hele-Shaw (acting as chairman in the absence of the president) to exhibit a series of lantern slides illustrating examples of conveying and elevating machinery not shown in the paper by Mr. Mitchell. The series embraced scraper, tray, rigid-arm and other elevators, and proved of great interest to members. Mr. Atherton felt that Mr. Mitchell's paper was, perhaps, of too comprehensive a character to lend itself to discussion.

Mr. Knight, in reply, agreed with all that Mr. Kininmonth had said in relation to the late Mr. Mitchell. Mr. Kininmonth had referred to the suspension of the pipes in the form of a balanced cantilever; the "bucket-elevator Mitchell" mentioned in Table II of his paper was worked on the same system. General Mowat had remarked that the bucket-elevator Mitchell was very much cheaper than any of the pneumatics shown in Table II; the actual figures in the table were 6·90*d.* per ton for the pneumatic and 6·84*d.* for the bucket elevator. To the last-named figure must be added the heavy charges, in the case of a bucket machine, for trimming round after reaching a certain depth in the hold. Therefore it could not fairly be said that the bucket elevator had much advantage over the pneumatic in respect to cost, apart from the question of dealing with cargoes separated by "mats." Referring to Mr. Reavell's remarks, he pointed out that a somewhat similar overload, or, rather, air-control device, had been tried on one of the turbos., but it operated on the difference in actual pressures rather than in the Pitot tubes, as mentioned by Mr. Reavell.

Dr. Hele-Shaw (acting as chairman) then brought the proceedings to a close, announcing that on January 6, 1922, there would be a joint meeting of the Institution and the Society of Chemical Industry. The paper to be discussed on that occasion was entitled "The Co-operation of the Engineer and Chemist in the Control of Plants and Processes," by Mr. G. M. Gill. There would also be an exhibition of scientific apparatus at the Imperial College of Science on January 4 and 5, and the councils of the Physical Society and the Optical Society invited all members to attend. Complimentary tickets could be obtained from the office.

NOTES.

THE MACQUORN RANKINE CENTENARY.

The late W. J. Macquorn Rankine was probably the most original thinker who has ever occupied an engineering chair at a British University, his only possible rival being James Thomson the elder brother of the better-known Lord Kelvin. Rankine was born in Edinburgh on July 5, 1820, and the centenary of this noteworthy event should accordingly have been celebrated last year. The omission has, however, now been made good, and last week Dr. Barr delivered a very interesting address on Rankine's career to the Glasgow Philosophical Society. He noted that although trained as a practical civil engineer, Rankine was refused membership of the Institution of Civil Engineers, being admitted only as an associate, a distinction which he resigned in 1857. His predecessor in the Glasgow chair of engineering was Gordon, and his inaugural address dealing with the connection between theory and practice, which is reprinted as the preface to his well-known treatise on "Applied Mechanics," has long been recognised as a classic. Rankine's professorship covered a period of seventeen years, during which both pure and applied science advanced with giant strides. New problems rendered past experience an insufficient guide for the designer of machines and structures, and Rankine made in all directions most important additions to our theoretical knowledge. Amongst the novel problems solved by him, was the important one of the stability of a granular mass. His solution led to important conclusions on the bearing power of foundations in such materials. He made also many important contributions to the science of naval architecture, but probably his work on thermodynamics was that in which his insight and originality were best displayed. He was the first to determine the thermodynamic efficiency of an ideal steam engine, being the inventor of the Rankine cycle. This discovery and others due to Rankine have been frequently attributed to Clausius, partly perhaps because physicists are prone to look on engineers as mere practicians. It must, moreover, be admitted that in his technical works Rankine's style is unattractive, although the inaugural dissertation to which we have already referred showed that on other matters he could rise to eloquence. His various treatises have, however, proved a prolific mine, in which writers of the more popular text-books have most industriously delved. His work covered, in all, a period of thirty years, during which he contributed no less than 158 original papers to various scientific and technical societies. He died in 1872.

MECHANICAL ENGINEERS AND THE FUTURE.

Normally one does not look for any common measure in the speeches which may follow a dinner, but if, while dealing each with the subject allotted to him, the speakers are able to glance at one of the several facets of a common problem the oratory as a whole is likely to form a more useful contribution to affairs than is usual. This effect was practically achieved at the annual dinner of the Institution of Mechanical Engineers on the 15th inst. We do not imagine that the effect was deliberate or even conscious, but we think it was present. The common subject which was dealt with may be shortly described as "Mechanical Engineers and the Future," by "the future" indicating the many social, political and economic problems with which the nation is now faced. The tone, and even the subject, were perhaps set by Dr. Hele-Shaw, who made the first speech after the loyal toasts had been given by Captain Sankey, the President, when a telegram was despatched to the Prince of Wales, who is an hon. member of the Institution. Dr. Hele-Shaw proposed the toast of "The Houses of Parliament," and raised the question of the economic difficulties through which the engineering industry is now passing. He also introduced the labour question and connected it with his toast by a reference to the labour members and the value to industry and to the State of the freedom of expression of opinion which labour enjoyed in the House. The Right Hon. Stanley Baldwin, who replied, spoke of the value of Parliament as the ultimate bed-rock of order, and pointed out that if Parliament failed nothing could follow but anarchy. Mr. Richard Allen, following with the toast of "His Majesty's Forces," left the broad general principles dealt with by the earlier speakers and dealt with the question of the cancellation of the warship contracts. No one can quarrel with his statement that we must have a Navy adequate to our Empire needs, while most engineers will certainly agree that retrogression in the Navy would mean a loss to scientific advancement. This toast was replied to by Sir William Robertson, who, while naturally confining his remarks mainly to the Army, was obviously in sympathy with the point of view adumbrated by Mr. Allen. One of his *obiter dicta* was that if we wanted a cheap army we must devise a cheap policy to fit it. Sir William paid a tribute to the work of engineers in the war, while their close connection with scientific progress was touched on by Mr. William Reavell and Mr. W. B. Worthington, speaking to and for "Kindred Societies." The point was gracefully enlarged on by Senatore G. Marconi in responding to Sir John Dewrance's toast of "The Visitors." Senatore Marconi spoke of the large amount of mechanical engineering involved in long-distance wireless telegraphy, and created much interest by his reference to the achievement of wireless communication from this country to Australia. The concluding speeches of the Right Hon. H. A. L. Fisher and the President touched on the question of the education of the engineer, which in view of his importance in the State daily becomes of more moment.

ALUMINIUM SOLDER.—The Deutsche Gesellschaft für Metallkunde offers a prize of 20,000 marks for an economical aluminium solder. The competition is, however, restricted to German subjects. Professor Heyn, director of the Materialprüfungsamt, is chairman of the committee, and competitors should send in their applications before July, 1922.

THE PARIS AERONAUTICAL EXHIBITION, 1921.

By Major R. H. Mayo, O.B.E., M.A., A.M.I.C.E., F.R.Aë.S.

(*Concluded from page* 797.)

The most noticeable feature of the Salon from the aerodynamic point of view is the lack of new developments; there is a strong tendency amongst French designers to standardise on the biplane of normal aerodynamic design and they are not disposed to experiment either on broad lines or in matters of detail design. Among the passenger or freight-carrying machines there is not a single monoplane or triplane except the Dutch Fokker machine, but what is even more striking is that all the machines, except the Fokker, follow stereotyped lines as far as their aerodynamic design is concerned. The Fokker machine employs the thick high-camber cantilever wing, on which the Dutch designer has specialised for some time past, but apart from this there is not a single important machine employing a wing section which is at all abnormal. Nor is there anything in the nature of variable camber wings or wings of variable area; in fact, the French designer seems to have accepted the standard of aerodynamic design attained at the end of the war as good enough for commercial purposes. He is content to produce a machine with a surface loading varying between about 8 lb. to 10 lb. per square foot on wings of normal section—generally very similar to the British R.A.F. 0·15—and argues that the landing speed is no higher than that to which military pilots became accustomed during the war. With this wing loading and a reasonably good wing section a highly efficient machine can be designed, and several French designers have made the most of the engines at their disposal to produce machines capable of carrying a substantial commercial load at a maximum speed of 110 m.p.h. to 120 m.p.h. Designers cannot bring themselves to see that, at the present stage of development of commercial flying, safety is more important than high speed, so they will not consent to reduce the surface loading. It is possible that when the Handley-Page slotted wing, or other wing which can be adjusted during flight from a normal wing to a high-lift wing, has been perfected, some designer will see that it will bring greater benefit to commercial aviation if applied in reducing landing speeds to a reasonable level than in improving the high standard of "performance" already attained.

The French designer has never really believed in designing for inherent stability. It has been a tradition since pre-war days that inherent stability can only be obtained at the expense of controllability. This idea became more than ever prevalent after the introduction of the B.E.2c areoplane, whose relatively sluggish controls were considered to be an inevitable consequence of inherent stability. However, the inherently stable aeroplane won the day as far as British design was concerned, and later researches proved that a stable machine can be made amply controllable by suitably designing the control surfaces. Whatever justification there may have been for a lack of stability in the fighting scout machine, there has never been the slightest doubt in the minds of British designers that the commercial machine ought to be inherently stable in every sense. French designers, however, are only half-hearted in their belief in the desirability of inherent stability; it is clear that they are paying a good deal of attention to the controllability of large and moderately large machines, but they still appear to believe that stability and controllability are essentially antagonistic. Some of the machines shown are stated to possess inherent stability, but in most cases this claim is obviously not justifiable, while there are several machines whose instability must be very pronounced. Most of the designers, however, make some attempt to obtain stability in the lateral sense by setting the planes with a small dihedral angle, but none of them employ the substantial dihedral angles which have characterised nearly all British designs for years past. The importance of directional stability has been more generally realised, and most of the machines carry a fairly large fixed fin at the tail.

On the other hand, most of the designers have made special efforts to obtain good controllability; the Latécoère machine, for example, is provided with elevators of the same area as that of the fixed tail surface, the elevators extending well beyond the tips of the tail planes. In this case, longitudinal stability has been sacrificed probably with the object of making the machine quicker on the elevator control, but this sacrifice of stability has long since been demonstrated to be unnecessary.

An interesting method of balancing control surfaces in order to lighten the effort required from the pilot is introduced on the big Farman B.N.4 bomber. The trailing edge of the aileron and elevator is fitted with an auxiliary hinged flap, this flap being connected by rods to the fixed plane in front of the aileron or elevator. Thus, when the aileron is moved downwards the auxiliary flap is compelled to move upwards relatively to the aileron and *vice versâ*. The effect of the auxiliary flap on the aileron is similar to that of the aileron on the wing, and it automatically acts so as to assist the pilot. On a big machine like the Farman this should prove to be an efficient method of balancing the control surfaces.

The importance of providing the pilot with a satisfactory means of trimming the machine during flight has been realised in one case, viz., the three-engined Potez type "X." This machine is provided with separate auxiliary fins and tail planes which can be adjusted in the air by the pilot; this feature will be of special value in the event of failure of one of the outboard engines, but for ordinary normal flying such a means of trimming the machine is of great assistance to the pilot.

The annexed table shows the leading characteristics of the more interesting commercial machines at the Salon.

Machine.	Engines.	Normal H.P.	Lifting Surface.	Weight in Pounds.			Weight per H.P.	Weight per Sq. Ft.
				Machine, Empty.	Crew, Fuel and Useful Load.	Total.		
							lb.	lb.
Ansaldo	One 300-h.p. Fiat ..	300	473	2,534	1,653	4,187	14·0	8·85
Blériot Spad 33 ..	One 250-h.p. Salmson..	250	461	2,315	2,205	4,520	16·5	9·8
Blériot Spad 45 ..	Four 275-h.p. Hispano-Suiza	1,100	1,563	7,716	7,716	15,432	14·0	9·9
Bréguet "Léviathan"	Four 225-h.p. Bréguet	900	1,509	6,614	7,716	14,330	15·9	9·5
Caudron C. 61 ..	Three 140-h.p. Hispano Suiza	420	1,121	4,850	2,822	76,72	18·25	6·84
Fokker	One 230-h.p. Siddeley "Puma"	230	452	2,645	1,542	4,187	18·2	9·3
Latécoère L.A.T.4 ..	One 500-h.p. Salmson and two 250-h.p. Salmson	1,000	1,703	9,921	5,963	15,884	15·9	9·3
Nieuport 30 T2 ..	One 420-h.p. Darracq Coatalen	420	886	4,630	2,112	6,742	16·0	7·62
Nieuport "Sesquiplan"	One 300-h.p. Hispano-Suiza	330	118·5	1,543	507	2,050	6·2	17·25
Potez IX	One 375-h.p. Lorraine Dietrich	375	496	2,756	1,764	4,520	12·0	9·2
Potez X	Three 180-h.p. Hispano Suiza	540	1,013	4,630	3,395	8,025	14·9	7·9

Of the machines included in the table all are commercial passenger-carrying machines, except the Nieuport "Sesquiplan."

It will be seen that the machines show a comparatively small range of variation either as regards weight per horse-power or surface loading, but the load carried, expressed as a percentage of the total weight, is widely different for the several machines. These differences arise mainly from the use of relatively heavy power plants in some of the machines. The Nieuport "Sesquiplan," included in the table by way of contrast, is, of course, designed purely for racing purposes, and the figures given show that, in its present form, it could not serve any commercial purpose. It was on this machine that the pilot Kirsch won the race for the Deutsch de la Meurthe Cup in October, recording a mean speed of 173 m.p.h. over the 300-km. course. It is beautifully designed as regards reduction of head resistance, but the wing loading employed is so high that the machine could only be successfully landed by the most expert pilot on a perfectly smooth aerodrome.

Several references have been made above to the fact that the French aeroplane designer is short of really suitable engines round which to design his machines. Only three French engines have figured at all prominently in the air transport services during the present year, viz., the 250-h.p. Salmson, the 300-h.p. Renault, and the 375-h.p. Lorraine-Dietrich. There is clearly a need for a rather more powerful engine, while the demand for greater reliability is as pressing as ever. Although a number of engines of powers considerably in excess of 400 h.p. are exhibited at the Salon, these, almost without exception, have been seen before—most of them at the Paris Salon of 1919. It is significant that aeroplane constructors continue to use the old and established types of engine for their new designs. The chief reason for this is that the more powerful French engines have not been able to demonstrate their reliability.

As practically every engine in the Salon has been described in the technical press at one time or another, no attempt need be made to describe them here, but special reference should be made to the one engine of outstanding merit, viz., the Bristol "Jupiter." This nine-cylinder radial air-cooled engine has recently demonstrated its reliability by successfully passing the British Air Ministry's type tests.* If further experience in the air under ordinary working conditions confirms the bench test results as to reliability, this engine will be a most attractive proposition to the aeroplane designer. The ungeared engine develops a normal brake horse-power of 400 at 1,600 r.p.m., for an overall weight of under 700 lb., while the fitting of an epicyclic reduction gear, bringing the normal revolutions per minute of the propeller down to 1,050, increases the overall weight to 805 lb. The weight per horse-power is thus considerably less than in the case of any water-cooled engine, and at the same time, of course, the elimination of water-cooling is a valuable simplification from the operational point of view. The accessibility of the radial engine is one of the reasons for the wide adoption of the Salmson engines in France, but the radial, air-cooled engine has considerable advantages in this respect over the radial water-cooled engine. A model exhibited at the Salon shows a simple method of mounting the "Jupiter" engine which can be standardised for any machine.

*See page 691 *ante*.

INDUSTRIAL NOTES.

Dealing with the labour market for November, the Ministry of Labour state that unemployment generally continued bad during that month. In some industries, including coal, iron and shale mining, tin plate and steel sheet manufacture, an improvement was reported, but in a number of others, including the engineering, shipbuilding, brick, cement, pottery and building trades, there was a further decline. The percentage unemployed among members of trade unions from which returns were received was 15·9 at the end of November, compared with 15·6 at the end of October. The percentage unemployed among workpeople insured under the Unemployment Insurance Act was 15·7 on December 2, as compared with 14·9 on November 4. The percentages for males and females on December 2 were 17·7 and 10·6 respectively. The total number of workpeople registered at the Employment Exchanges as unemployed

on December 2 was approximately 1,834,000, of whom 1,415,000 were men and 318,000 were women, and the remainder were boys and girls. On November 4 the number on the live register was 1,729,000, of whom 1,332,000 were men and 294,000 were women. In addition to those unemployed, 155,000 males and 113,000 females were registered on December 2 as working systematic short time in such a manner as to entitle them to benefit under the Unemployment Insurance Act. On November 4 the corresponding figures were 153,000 males and 99,000 females. The number of vacancies notified by employers to Exchanges and unfilled on December 2 was 18,100, of which 4,400 were for men and 11,800 for women, compared with 19,600 on November 4.

Changes in rates of wages reported as having come into operation in November, in the industries for which statistics are compiled by the department, resulted in a total reduction of approximately 1,150,000*l.* in the weekly full-time wages of over 3,450,000 workpeople. The wages of coal miners were reduced in all districts as a result of adjustments made on the basis of the proceeds of the industry in September, the decreases on the rates current in October varying from 12 per cent. to 30 per cent., and exceeding 20 per cent. in most districts. In the engineering and shipbuilding trades one-third of the bonuses of 12½ per cent. and 7½ per cent. on earnings granted in 1917 and 1918 to adult male time-workers and piece-workers, respectively, was withdrawn. There was a reduction of 45 per cent. on the standard rates of steel melters (equal to about 19 per cent. or 21 per cent. on current rates). Tin-plate makers in South Wales and Monmouthshire sustained a net decrease equivalent to about 19 per cent. on current rates. There were also numerous reductions under the operation of sliding scales by which wages fluctuate with the index numbers of cost of living, the workpeople affected by such reductions, including civil engineering workers, women and girls in the engineering trade, brass, bedstead, hollow-ware and edge tool workers in the Midlands, electric cable makers, silversmiths and jewellery, &c., road transport workers in Scotland, furniture trade operatives in various districts, vehicle builders, coopers, and employees of gas, electricity and tramway undertakings. Since the beginning of 1921 changes in rates of wages reported to the department have resulted in a net reduction of 5,560,000*l.* in the weekly wages of nearly 7,000,000 workpeople, and a net increase of 20,000*l.* in the wages of nearly 120,000 workpeople.

The number of trade disputes involving stoppages of work reported to the department as beginning in November was 74. In addition, 47 disputes, which began before November, were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in progress at any time in November (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 36,000, as compared with 25,000 in the previous month, and 1,138,000 in November, 1920, when a dispute involving over 1,000,000 workpeople was in progress in the coal mining industry of Great Britain. The estimated aggregate duration of all disputes during November was about 250,000 working days, as compared with nearly 200,000 days in October, 1921, and 3,500,000 days in November, 1920. The estimated aggregate duration of all disputes reported as in progress during the first eleven months of the present year was about 88,000,000 working days. The total number of workpeople involved in these disputes was approximately 1,700,000. In the corresponding period of 1920 nearly the same number of workpeople were involved in disputes having an aggregate duration of approximately 27,000,000 working days.

On December 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 99 per cent. above that of July, 1914. This figure is the lowest recorded since May, 1918. The corresponding figure for November 1, 1921, was 103 per cent., and that for December 1, 1920, was 169 per cent.

In his weekly summary of the coal industry, No. 8, Mr. Philip Gee, 40, King-street, Covent Garden, W.C. 2, dealing with American competition, states that American exporters, having tasted success in the neutral markets, are preparing to put up a hard fight to obtain a substantial share of the British trade, and in this they are receiving the full support of the United States Department of Commerce. The question of shipping freights is being carefully examined, and the coal-carrying railway lines are also considering a substantial cut in export rates to increase the volume of rail-borne traffic. Further, a careful eye is being kept on the British coalfields in case unrest and dissension may again give American exporters the chance of turning British domestic troubles to profitable account. These American activities call for close co-operation between all the industrial organisations concerned in the maintenance and progress of the British export trade, namely, collieries, shipping and railways. For any one of them to take a narrow sectional view of the situation is calculated, at this juncture, to prove disastrous.

Sir Hugh Bell, Bart., chairman of the Cleveland Mine Owners' Association, and Mr. Alfred Hutchinson, chairman of the Cleveland Ironmasters' Association, have written to the *Newcastle Daily Chronicle* pointing out that the Cleveland iron trade, like the iron and steel trades throughout the country, has been in a stagnant state since April last, when the coal stoppage began. Makers, they say, have taken every course open to them in order to reduce prices so that they could obtain trade, and in their opinion there is one factor left that is likely to ease the situation, namely, a drastic cut in railway dues. The enormous advance in railway rates since pre-war days is a heavy handicap to trade. Taking the 1914 figures as 100, the following figures show the approximate railway rates on raw materials used to make pig-iron: On coal 221, coke 218, ironstone 240, limestone 226, other ores 244. A total of 5 tons to 6 tons of these materials is required to make 1 ton of pig-iron. The railway charges per ton of pig-iron in July, 1914, as compared with October, 1921, were as follows:—

	July, 1914.	October, 1921.	Increase.
	s. d.	*s. d.*	per cent.
From Tees—			
To Tyne	3 6	7 6	114
To Glasgow	8 10	18 2	106
To Leeds	4 9	10 0	111
To Sheffield	6 3	13 0	108
To Manchester	8 8	17 10	106
To Birmingham	11 3	23 0	104
To South Wales	14 9	30 0	103

The Cleveland employers have no hesitation in stating, continues the letter, that so long as their trade is burdened with such heavy railway charges, it will be impossible for them to restart their works on the old scale, and consequently, thousands of men who have always found employment in the iron trade will find it incumbent upon them to seek a fresh calling. The price of Cleveland pig-iron has fallen from 225*s.* per ton at the beginning of the year to 100*s.* per ton to-day, but this figure is several shillings per ton higher than the price at which Continental pig-iron can be delivered on the Tees.

We read in *The Iron Age* that in addition to changes being made in the schedule in the United States census of manufacturers for 1921, one question prepared by the Secretary of Commerce that is taken to be significant is being introduced. The question to be answered by manufacturers is an inquiry as to the estimated percentage of output compared with possible output "if you had had such demand as to require full running time."

In view of the expansion in the steel industry, especially in some departments such as those making plates, the Government, our American contemporary adds, is trying to assist manufacturers in developing export markets so as to absorb the surplus output above domestic requirements. It is believed that the question, incorporated at the direction of Mr. Hoover, has a bearing on this subject.

The following notes are taken from the report by Sir Arthur Dorman, read at the thirty-second ordinary general meeting of Messrs. Dorman, Long and Co., Limited, held last week. Scrap was being sold at prices pounds below the cost of pig-iron, with the result that for the moment it was better to buy scrap than to make pig-iron for use in the steel furnace. The company had, therefore, been constrained to let the larger part of their blast-furnace plant stand idle to their great inconvenience and loss, with the still more serious consequence that large numbers of their men, both at the iron works and the ironstone mines, were thrown out of employment. Out of 32 blast furnaces, only six were at work, one on hematite, one on ferro-manganese and four on basic iron. The company had decided to extend their business in Australia by opening a constructional yard at Sydney, for which purpose they had purchased a suitable site. In regard to their interest in Kent, under present conditions and with prices as high as they were at the moment, they were limiting their expenditure to the amount that was necessary to fulfil their obligations under the leases and options they held in that county. Speaking generally, the company were trying to adjust their cost to the demand of buyers, but it was not an easy matter, and could not be achieved without sacrifices and suffering all round. The company had considered their moral obligation to provide work to support their men and their families, and had kept the works going at a time when there was little or no profit in so doing. They had also to consider the interests of their shareholders and to bear in mind that they could not conduct their business indefinitely without profit.

According to the *Corriere d'Italia*, quoted by the Commercial Counsellor to H.M. Embassy in Rome, of the 268,000,000 lire provided by the Italian Government to alleviate unemployment by the undertaking of public works, the greater part will be apportioned as follows: 61,000,000 lire for the repair of bridges and roads; 78,000,000 lire for hydraulic works (improving the navigability of the River Po, the embankments of the Rivers Tiber and Arno, &c.); 50,000,000 lire for harbour works; 15,000,000 lire on drainage and sea coast works, &c.

The trade review for the current year issued by Messrs. Bolling and Lowe, Limited, calls attention in its opening statements to the present difficulties which surround British trade. According to this old-established firm, taxation must be substantially and promptly reduced, otherwise it is not difficult to foresee that within a few years only a limited number of concerns will be in a position to meet the extravagant demands for national services. The excess profits duty has now ceased, it is true, but its ill-effects upon trade are apparent by the shortage of cash and the increased borrowings by industrial companies to enable them to carry on, the borrowings being in the form of debentures, short term notes, &c., to the detriment of existing shareholders. The increased cost of postal, telephone and telegraph services is found to be hampering trade in every direction. After reviewing the situation in various countries and quoting a series of prices ruling at various times for metals, plates, bars, rails, &c., the firm state that the prospects for 1922, at any rate for the last six months of that year, are brighter than they have been of late, and they look forward with confidence to the future.

The latest issue of the Bulletin of the Federation of British Industries gives a copy of the letter addressed by the president to the Chancellor of the Exchequer stating that any attempt to maintain taxation at its present level during the forthcoming year must at best seriously retard any industrial recovery, and at the worst may involve a permanent diminution in the productive capacity of the country. The evidence brought forward by representatives of all industries shows that the present rate of taxation is stifling initiative, postponing development, and crippling the efforts of manufacturers to recover and extend the foreign markets which are now of such vital importance to the welfare of the country.

A meeting of the Railway Managers' Association was held last Tuesday at the Railway Clearing House, London, when the English and Welsh railways decided to reduce the rates for the transport of the following goods as follows: Coal, coke and patent fuel; limestone for chemical works; lime in class B of the general railway classification for iron and steel-making purposes; iron and steel in class B of the same classification. The increase in the base rates in operation on January 14, 1920 (at present 100 per cent.), will be reduced to 75 per cent.; the present flat rate of 6*d.* per ton will be reduced to 4*d.* per ton; the maximum addition of 4*s.* per ton, where applicable, will be retained. The reductions are to take effect as from January 1. The railways estimate that they will mean a decreased revenue to them of 10,000,000*l.* per year. The new tariffs for the above goods are to be applied experimentally for a period of twelve months. Manufacturers throughout the country anticipated that a greater reduction than the above would be granted by the railway companies. Considering the rates from the point of view of Sir Hugh Bell and Mr. A. Hutchinson, the reduction for the particular industries dealt with will probably not meet the case. Other trades are also claiming reductions in tariffs.

DIESEL ENGINES IN SWITZERLAND.—In a paper on "Diesel Motors, their Construction and Comparative Economy," read on November 23 before the Zürich Ingenieur und Architekten-Verein, Chief-Engineer Alfred Büchi, of Winterthur, combated the view that a Diesel engine could not compete with water power in Switzerland, and his view found support by F. Gugler and by members generally. M. Büchi does not advocate the Diesel engine as a substitute for water power, but as supplementary to it, especially in cases where an occasional peak load has to be met or when power is wanted intermittently for relatively short periods.

PNEUMATIC GRAIN ELEVATORS.*

Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators.

By R. E. KNIGHT, M.C., of London, Associate Member.

Introductory.—Bucket-elevators have certain advantages for handling grain in bulk, and many of these elevators are in use in the Port of London. The merits of this class of machine are before the Institution in a Paper on "Conveying and Elevating Machinery," by Mr. Gardiner Mitchell. The present Paper deals only with the pneumatic discharge of grain from ships; and more particularly with two modern examples of floating and quay-side plants in which oil-engines or motors, and high-speed rotary exhausters, have replaced the more usual vertical or horizontal compound steam-engines and reciprocating exhausters, as the main power-plant of the installation.

Reference to the Papers in the bibliography will show that the invention of the pneumatic elevator on a commercial basis appears to be due to the late Mr. F. E. Duckham.

General Principles of a Pneumatic Elevator.—Some form of power plant driving some form of air-exhausting plant, together with the necessary fuel, is enclosed in a steel pontoon or hull. On the deck of this hull, or at a suitable distance above it, is placed a grain receiver or canister to which the air-exhausting plant is connected. Suitable internally-armoured flexible and/or rigid pipes provided with nozzles are led from the canister to the grain in the hold of the craft to be discharged. These nozzles are kept buried in the grain, air rushes up the pipes in an endeavour to destroy the vacuum permanently maintained in the circuit, and in so doing carries the grain with it, which is deposited in the canister. By means of an automatic or mechanical air-lock of the tipper or rotary-wheel valve type, the grain is continuously discharged from the canister (without loss of vacuum therein), to some form of grain hopper situated at a suitable height above the deck, whence the grain is delivered either direct to craft or weighed out thereto through scales and chutes either in bulk or sack as may be required. The higher the proportion of grain raised to air displaced at any given vacuum, the more efficient will the machine be, and the less horse-power per ton of grain raised will be required. Such efficiencies are usually in the neighbourhood of 5 per cent. or less.

Advantages for Discharge of Grain ex Ship.—In spite of the very low order of efficiency obtained from pneumatic plants, they have many advantages for ship discharge, which will be found set out in detail in the Papers referred to in the bibliography. They may be here summarised as under:—

(*a*) No reasonable limitation as to size of ship discharged.

(*b*) Can work any kind of parcel and any method of stowage with special advantage in cases where different parcels are stowed superimposed in the same hold and separated from each other by "mats" only.

(*c*) Simplicity and rapidity of shipping and unshipping.

(*d*) Absence of "trimming" in the hold and dust thereby entailed.

(*e*) No damage or loss of weight to grain, but on the contrary aeration and cleaning during discharge.

(*f*) Use of ship's gear not required.

(*g*) Other cargoes can be removed from between decks whilst discharge is being effected.

(*h*) Work in bad weather due to minimum removal of hatches over hold.

(*i*) Permanent crew from numerical standpoint about the same; but extra labour for ploughing gangs in the hold, and winch end men on the ship's deck are eliminated, as are also the heavy charges for ropes, ploughboards, and other gear.

(*j*) Output in tons per hour may be higher and usually is so; the rate of discharge for all types of machine, however, depends on the rate of delivery from the scales rather than on the maximum intake capacity of the plant, and therefore the conditions of delivery must largely affect the final rate of output.

(*k*) Reliability and freedom from breakdown caused by obstructions due to foreign matter in the grain or other cause.

(*l*) Costs of working and maintenance may be broadly regarded as being made up of engineering charges and bulk grain charges. It will be seen from the Table referred to later, which gives the engineering charges only, that the pneumatic elevator compares favourably in this respect—except in the matter of capital cost.

The general tendency of modern docks is to instal pneumatic machines for floating discharge ex ship.

Tabular Statement of Leading Features.—The leading features of the various floating pneumatic plant working in the London docks are set out in Table I.

It will be seen from the table that these machines may be grouped as under:—

Group A.—This group comprises the machines first constructed in which the hull is of rectangular box section; the power-plant marine boilers, together with vertical or horizontal steam-engines and horizontal reciprocating exhausters coupled thereto, either through gearing or direct; the superstructure either one or two towers, in which the grain canister and pipe-lines are superimposed over the grain hopper, giving discharge to craft through scales and chutes; and the working position of the elevator "side on" to the ship under discharge.

Group B.—This includes machines subsequently constructed or converted, in which the hull power and air-exhausting plant are similar to Group A, but in which the superstructure consists of a single grain-canister and pipe-line placed on the forward end of the pontoon; the grain is re-elevated therefrom by bucket-elevator to the grain-hopper and weigh-house on the after end of the pontoon, whence maximum discharge can be effected to craft on either side of the elevator or any desired proportion thereof to craft on both sides of the elevator; and the working position of the elevator may be either "side-on" or "end-on" to the ship under discharge, the pipe-line being slewable for this purpose.

Group C.—This group comprises the machines most recently constructed to the requirements of the Port Authority and the designs of their Chief Engineer, assisted by the late Mr. A. H. Mitchell, the special features of which are briefly dealt with hereafter. In designing these machines for use in London docks the following were the main requirements:—

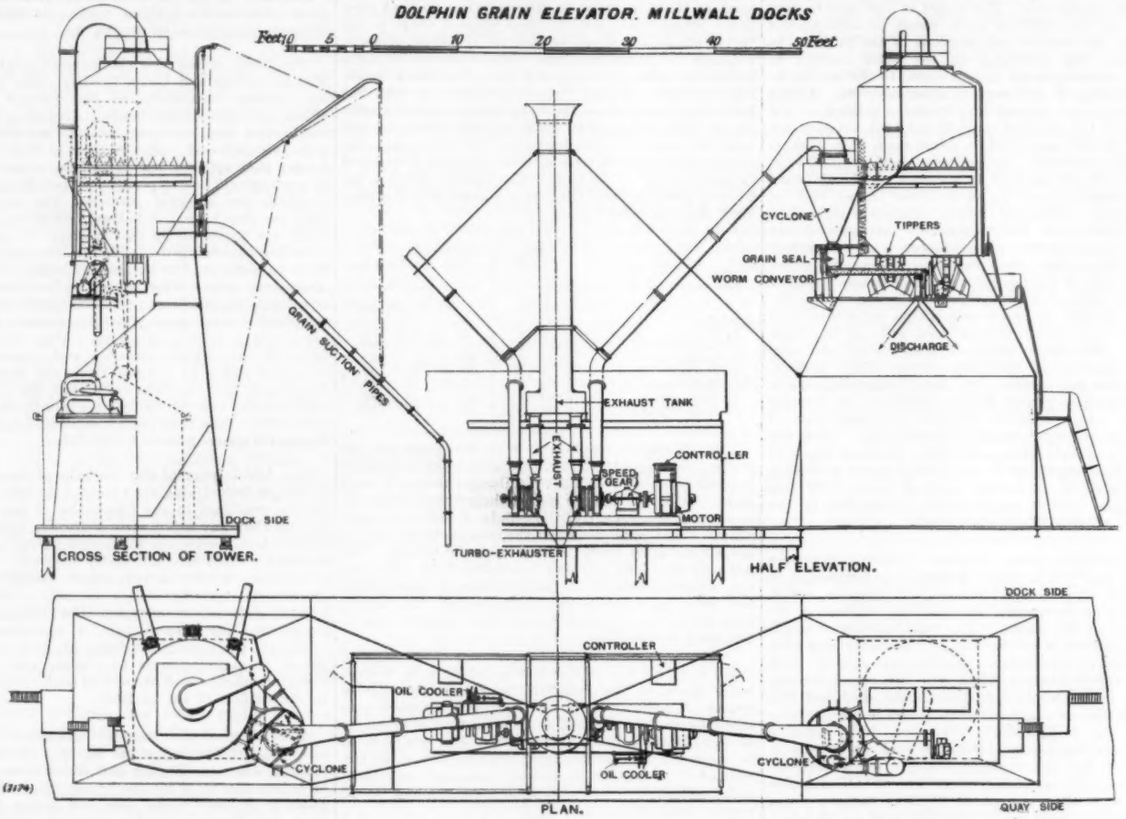
The Hull should be as small in dimensions and raft, as conditions of stability permit; should be manœuvred about any dock by power-winch and rope; and should tow from dock to dock in safety.

The Power-Plant should give a minimum of maintenance and stand-by charges for intermittent working of machines.

Superstructure.—To discharge wheat in bulk ex ship at the rate of 100 tons per hour in either the "side-on" or "end-on" positions and is to be so arranged that:—

(i) There is the necessary margin of stability for the vessel.

(ii) The pipe-lines can be shipped, unshipped, and manœuvred in the hold with rapidity.



(iii) That the length and disposal of the permanent portion of the pipe-line attached to the elevator shall be such that the supplemental labour charges for the addition of further pipe-line are a minimum.

The method of effecting these requirements is hereafter briefly described.

DETAILS OF DESIGN OF PLANT: GROUP "C."

The Hull.—Reduced to 60 ft. long by 30 ft. wide at deck level, depth 11 ft. 6 in. and about 6 ft. 8 in. loaded draft—sides of pontoon raked and made swim-ended fore and aft, and provided with budget plates for ease of towing.

The Engine.—The obvious disadvantages of a steam-plant for intermittent working are the space occupied by, maintenance of, and attendance on, the multitubular marine-type boiler—whether the machine be working grain or idle; and the cost of loading stowing and handling the coal therefor.

A 200-h.p. four-cylinder vertical semi-Diesel oil engine made by Messrs. Vickers Petters was fitted, and is of their standard VJ 4 type. Normal running speed is 250 r.p.m., but an auxiliary hand-operated governor is provided to enable the engineer to vary this within limits for the different classes of grain to be worked. Fuel is Anglo-American or other approved gas-oil of a specific gravity of about 0·86 and flash-point of 150° F.; fuel consumption is ½ pint per b.h.p.-hour, and about 3,000 gallons are carried in two cylindrical tanks disposed inside and one on each side of the pontoon. Starting up is by compressed air, blow lamp, ignition tube, &c., and can be effected in less than three minutes from cold. A large fly-wheel is fitted to minimize cyclical variation. Cooling is by circulation of dock water to engine-jackets; there is no water injection to cylinders. The engine exhausts are carried about 30 ft. above deck level and are

* Paper read before the Institution of Mechanical Engineers, December 16, 1921.

PNEUMATIC GRAIN ELEVATORS.

TABLE I.—PARTICULARS OF MACHINES.

Name. Displacement in Tons. When Built.	Power Plant.				Grain Canisters.		Cyclones or Stive Rooms. Capacity in Cub. Ft.‡	Grain Intake Pipes.					Weigh-House.			Remarks.		
	Engine.	Pumps.	Drive to Pumps.	Pump Constant.*	No. of	Capacity in Cub. Ft.‖		No. of.	Diam. in Inches.	Horizontal Drag.	Vertical Lift.	Type of Nozzle.	No. and Type of Scales and how Placed.	Height from Floor to Water Level.	Diam. of Discharge Chutes.	For Wheat. Discharge. Normal Engine Speed.	For Wheat. Discharge. Normal Vacuum. In. Hg.	Group Letter.
"Rapid." 1,000. 1905.	Steam. Horizontal Compound surface condensing. Stroke 48". H.P. 28" | DA L.P. 54" / cylinders	4 DA horizontal pumps. Bore 4' 1". Stroke 4'	Tail-rods from pistons	420	2	1,700	2,000	8. Four per Canister.	6	30' of 6" parallel.	70' of 6" parallel.	6" Bent	14 Avery autos at 250 lb. 7 each house, one side only.	18' 6"	7" sq.	50	7"	A.
"Mark Lane No. 2" 520. 1897.	As above. Stroke 48". H.P. 22" | DA. L.P. 42" / cylinders.	2 pumps as above. Bore 4'. Stroke 4'	Tail-rods from pistons.	200	1	1,800	3,300	4	6	30' tapers 10" to 6".	70' of 6" parallel.	6" straight	10 hand lever. 5 each side of house†	12"·3"	7" sq.	40	8"	A.
"Mark Lane No. 3." 880. 1902.	As above, but vertical. Stroke 30". H.P. 19" | DA. L.P. 38" / cylinders.	4 pumps as above. Bore 4'. Stroke 5'.	3 to 1 gear reduction from engines.	500	2	460‡	2,500	4. Two per canister.	7	34' tapers 12" to 8'	70' tapers 8" to 7"	7" bent.	12 hand lever. 6 each house, one side only.†	13' "9	6" sq.	70	10"	A.
"Chicago." 610. 1898. Reconstructed 1911.	As above. Horisontal. Stroke 48". H.P. 22" | DA. L.P. 42" / cylinders.	2 pumps as above. Bore 4' 6". Stroke 4'.	Tail-rods from pistons.	254	1	520	330	2	7	40' tapers 15" to 12".	50' tapers 12" to 7"	7" bent	6 Avery autos at 250 lb. placed centrally.	24' 0"	6½" round.	36	10"	B.
"New York." 650. 1902.	As above. Stroke 48". H.P. 22" | DA. L.P. 40" / cylinders.	2 pumps as above. Bore 4' 8". Stroke 4'.	Tail-rods from pistons.	272	1	2,000	1,200	4	6	30' tapers 15" to 8"	50' tapers 8" to 6"	6" bent	8 Avery Autos at 250 lb. 4 each side of house.	15' 0"	9" sq.	40	9"	B.
"Turbos 1 and 2." 350. 1916.	Oil. 4-cylinder vertical semi-Diesel. 200 b.h.p. 250 r.p.m.	4-stage rotary exhauster. 8,000 cub. ft. air per min. at 9" Hg. at 2,700 r.p.m.	Oil-cooled double helical speed increasing gear. Ratio 10 to 1.	—	1	150	600	2	8	45' tapers 18" to 12".	40' tapers 12" to 8"	8" bent.	6 Avery Autos at 250 lb. placed centrally.	23' 4"	8" round.	Exhauster Speed 2,400	7"	C.
"Dolphins Millwall." 4 Towers. 1921.§	D.C. Motor. 200 b.h.p. at 540 r.p.m. Voltage 460.	3-stage rotary exhauster. 6,000 cub. ft. Air per min. at 11" Hg. at 3,500 r.p.m.	Oil-cooled double helical speed increasing gear. Ratio 6½ to 1.	—	1	2,000	200	2	7	30' tapers 10" to 7"	50' of 7" parallel.	7" taper	10 hand lever. All on one side between Dolphin and quay.†	27' 0"	6" round.	Exhauster speed 3,250	10"	—

* The "Pump constant" gives the volume of air per revolution displaced by the total number of pumps fitted. Clearances and tail-rods, areas, &c., have not been deducted therefrom. † Shortly to be replaced by Avery Automatic scales at 250 lb.
‡‡ Has been reduced to size given by internal baffling. § All four towers are similar; the particulars given are for one tower only. The date 1921 is for reconstruction. Plant was built in 1903. ‖ Approximate only from over-all dimensions.
Horizontal drag is that length of horizontal or partially horizontal pipe-line which is carried permanently attached to the canister.
Vertical lift is that length of vertical piping which has normally to be added to the permanent vertical pipe-line carried in order to work a ship.

provided with silencers, water sprays, &c., also handholes to facilitate periodical cleaning.

The Air-Exhausting Plant.—On account of the large volume of air to be dealt with at low pressure, any type of reciprocating exhauster, whether horizontal or vertical, must be fitted with a number of inlet and exhaust valve of large area; or a greater number of valves of small area. The Port Authority has no plant to date fitted with vertical reciprocating exhausters; but there is no doubt that the maintenance of these valves is a big item for the horizontal type. Dust gets between the valves and their leather, rubber or other form of seating; which is rapidly eaten away with a consequent drop in efficiency, and stoppage of the plant for renewals; this also applies to the cylinders themselves with the piston and/or junk rings therein. For these and other reasons it was decided to abandon reciprocating, and fit rotary, exhausters. The exhauster fitted is of the "Rateau" pattern, four-stage single flow made by Messrs. Fraser & Chalmers of Erith, and was designed to be capable of dealing with a quantity of free air equivalent to 8,500 cub. ft. per minute maintained at a vacuum of 9 in. of mercury below atmospheric pressure, at a temperature of 60° F., when running at 2,700 r.p.m. Forced lubrication is provided for all main bearings. The joint in the casing is horizontal, and tackles, &c., are fitted to facilitate inspection of the rotor impellers. The exhaust is carried about 30 ft. above deck level, is placed remote from the engine exhaust, and is provided with a form of flap valve to eliminate any effects of back pressure due to surging. No maintenance or other charges have been incurred with this portion of the plant, which has been at work since 1916; and, due to the large and efficient dust cyclone fitted, no appreciable wear is visible on the rotor impellers.

The oil-engine is connected to the exhauster by double helical oil-cooled gears made by Messrs. David Brown of Huddersfield. The ratio of speed increase is about 10 to 1. Flexible couplings made by Messrs. Wellman Bibby Company, Limited, of London, are interposed between the oil-engine and the gears, and the gears and the exhauster. The reduction on the cost of running the elevator as a whole effected by fitting the above described type of main power-plant may be seen from the Table II of cost referred to later.

Design of Superstructure.—The general lay-out of this portion of the plant can be seen from drawings* published in the technical press. The plant was built by Messrs. Henry Simon, Limited, of Manchester. The pipe-crane and pipe-line are arranged for slewing for either "side-on" or "end-on" working; also for luffing for rapidity in getting in and out of a ship's hold, and for variations in the beam and freeboard thereof. The principle of the auxiliary elevator from grain canister to grain hopper is retained in order to ensure stability on the relatively small hull. The whole of the pipe-boom complete is carried attached to the elevator and is provided with permanent vertical telescopic portions to minimise the length of additional pipe required to work a ship, and the supplemental labour charges incidental thereto as previously referred to. The operation of the pipe lines and extra lengths of pipe is effected by motor-driven winches, &c., attached to the pipe-crane and is controlled from a driver's cabin. These motors are supplied from an auxiliary generating set of the oil-engine-cum-dynamo type. This auxiliary set also supplies power for the bucket-elevator motor, the grain tipper, the dust cyclone wheel valve and worm, the deck capstan, the air-compressor, bilge pump and fan, fuel pump, &c., and also for the lighting throughout the vessel.

* *The Engineer*, Feb. 28, 1919.

Conversion of Power-Plant at Millwall Docks.—A full description of the arrangement of the pneumatic intake plant at the Dolphins central granary, Millwall Docks, prior to conversion, will be found in the papers referred to in the bibliography. Briefly, it consisted of a wooden staging or dolphin standing at about 50 ft. from the central granary quay; and being about 350 ft. long, 25 ft. wide and 14 ft. above Trinity high-water level. The superstructure on the deck of this dolphin consists of four pneumatic grain-handling towers of the Group A type, complete with necessary grain-pipes, hand-lever scales, &c. This superstructure has been or is only to be altered in two respects:—

(*a*) Dust cyclones, wheel-valves and worm-conveyors of Group C type have been added for the better protection of the rotary exhausters to be described hereafter.

(*b*) The hand-lever scales are being replaced by Avery automatic scales.

The power-plant consisted of boilers, steam-engines and horizontal reciprocating exhausters of the Group A type, housed beneath the deck of the dolphin, and it is the whole of this plant which has been replaced by four sets of Group C type power-plant operated by electric motors instead of oil-engines. The four sets (one per grain-tower) are arranged in pairs, each pair being enclosed in an engine-house standing upon the deck of the dolphin it has therefore been possible to complete the erection of the new plant before discarding the old, thereby keeping the plant in commission throughout. The general lay-out of the new plant is shown in Fig. 1; all four sets are identical, and a brief description of one set is given below.

Motor-driven Rotary Exhauster Sets.—These were constructed by Messrs. Reavell, of Ipswich. Each set consists of a motor with necessary starter, &c., connected through flexible coupling to oil-cooled speed-increasing gear, which is again connected through flexible coupling to a high-speed rotary exhauster; the whole of the unit is carried on one common bedplate.

The Motor is of the open protected type, compound wound and fitted with interpoles. It works with direct-current at 460 volts pressure; shunt regulation of speed from about 360 r.p.m. to 600 r.p.m. Horse-power, 200.

Speed-increasing Gear.—Both flexible couplings are of the pin and rubber bush type. The gear is of the double helical type and is oil-cooled, the oil being circulated to gears and bearings being pump-driven through worm gear off the main low-speed shaft; a magnetic oil-strainer and cooler is provided. The oil pressure is between 6 lb. and 10 lb. per square inch, and a gauge and relief valves are fitted. Water for the oil-cooler is provided by a small rotary pump driven by belt from the low-speed coupling. The ratio of speed increase is about 6½ to 1 and a tachometer is fitted.

The Exhauster.—The rotor consists of three impellers

PNEUMATIC GRAIN ELEVATORS.

TABLE II.—COSTS OF WORKING OF MACHINES. YEAR 1919-20.*

Name and Group.	Working.			Fuel Consumption.						Costs in Pence per Ton of Grain.			Total Cost (pence) per Ton of Grain Raised.†	Remarks.
	Tons.	Hours.	Tons per Hour.	Electricity. Unit.	Oil. Gall.	Coal. Tons.	Tons Grain per Unit.	Tons Grain per Gal.	Tons Grain per Ton.	Wages.	Fuel and Stores.	Maintenance.		
"Rapid" A	88,174	1,183	75	—	—	950	—	—	93	4·27	5·68	3·22	13·17	Steam. Two Tower Machine.
"Mark Lane 2" A	60,468	1,027	59	—	—	460	—	—	131	4·33	3·82	4·33*	12·48	Steam. Single Tower Machine. Deduct 1 penny per ton from maintenance for unusually large boiler repairs.*
"Mark Lane 3" A	76,734	1,424	54	—	—	620	—	—	123	3·82	3·54	1·48*	8·84	Steam. Two Tower Machine. Cost of maintenance unusually low as machine only had 3 overhauls in year instead of 4.*
"Chicago" B	72,292	1,179	61	—	—	601	—	—	120	4·03	4·41	2·27	10·71	Steam. Single Tower Machine.
"New York" B	56,683	870	65	—	—	446	—	—	127	5·56‡	3·80	3·47	12·83	Steam. Single Tower Machine.
"Turbo 1" C	69,154	4,214	57	—	11,902	—	—	5·8	—	3·09	2·37	1·44	6·90	Oil. Single Tower Machine.
Bucket-Elevator "Mitchell"	47,046	768	61	—	—	30§	—	—	1,585	3·33	0·55	2·96	6·84	Bucket-Elevator. Slewing and luffing cantilever type. Suction gas.
Bucket-Elevator. Nos. 1 to 8 elevators and 2 steam barges.	111,911	2,215	51	—	—	258	—	—	436	5·97	1·67	5·62	13·26	Steam. Elevators and conveyors hand rigged.
Bucket-Elevators A B C D	76,616	1,444	53	29,740	—	—	2·58	—	—	3·76	0·69	5·05	9·50	Motors. Elevators and conveyors hand rigged.

* The above are engineering division working costs only, exclusive of general charges interest and depreciation.
† Deductions as shown in "Remarks" column; being cost per ton of abnormal or unusual charges on ordinary maintenance; should be made in order to arrive at a normal total cost per ton for the year.
‡ It will be noted that generally speaking wherever the cost in pence per ton for Wages is high the tonnage handled for the year is low. § To nearest ton.

TABLE III.—AVERAGE TEST RESULTS FOR GROUP C MACHINES.

Machine.	Length of Pipe-Line in Feet.	Quarters of Grain.†	Net time in Hours.	Main Engine. Fuel Consumed in Pints.	Quarters per Hour.	Tons of Grain per Hour.*§	Pints of Fuel per Hour.	Pints 1·0 = B.H.P.‡	B.H.P. per Ton per Hour.	Average. Results for Ten Tests on *each* Machine in 11 Different Ships.‖
Turbo 1	72	2,560	8	584	321	71	73	122	1·72	Engine speed, 250 r.p.m. Vacuum, 7".
	85	2,933	9	720	326	72	80	133	1·85	Quarters of grain per hour, 304. Tons per hour, 67.
	90	1,179	3½	270	314	70	72	120	1·72	Pints of fuel per hour, 76. Length of pipe-line, 83'.
	90	1,709	6½	487	263	58	75	125	2·16	B.H.P. = 127. B.H.P. per ton per hour = 1·9.
Turbo 2	70	2,767	7	453	395	87	69	115	1·35	Engine speed, 250 r.p.m. Vacuum, 7".
	80	3,000	9	634	333	74	70½	117	1·59	Quarters of grain per hour, 325. Tons per hour, 72.
	90	1,532	5	370	306	68	74	123	1·81	Pints of fuel per hour, 73. Length of pipe-line, 83'.
	104	1,383	5½	423	251	56	77	128	2·28	B.H.P. = 121. B.H.P. per ton per hour = 1·68.

* Wheat assumed at 4·52 quarters per ton.
† All results are for wheat discharge as weighed out *through* scales.
‡ Fuel consumption assumed at 0·6 pint per b.h.p.-hour.
§ Tons per hour from Table 2 = 57.
‖ Average for the two machines over the twenty tests = 1·78 b.h.p. per ton of grain per hour.

mounted on a rigid shaft revolving in roller bearings; there is a thrust bearing and two main roller bearings which are supplied by the gear-case oiling system and return their oil to the common sump. Attenuated air is led from the cyclone to the exhauster inlet and is discharged at or slightly above atmospheric pressure on the outlet, a butterfly valve being fitted in the inlet or suction opening. The suction side is connected to a 30-in. mercury gauge and an automatic dial type vacuum recorder; and the delivery side is connected to a 30-in. water gauge. The duty of the exhauster is to aspire 6,000 cub. ft. of attenuated air at a pressure of 11 in. of vacuum (Hg) and to compress this to atmospheric pressure for delivery. These conditions are fulfilled when the motor speed is about 540 r.p.m. and the exhauster speed about 3,500 r.p.m. If the motor speed be raised to 600 r.p.m., the exhauster speed becomes 3,900 r.p.m., and a maximum vacuum of 14 in. Hg may be obtained.

Switch Gear.—Elaborate switch gear is fitted with the object of preventing the motor being subjected to heavy overloads either during starting up or under running conditions. This switch gear is not vital to the plant and will not be described here.

Operation of Plant.—The conversion has only been effected for a few weeks, but during this period the plant has run well. For this reason it has not been possible to include any figures for the plant under Table II.; it is, however, certain that the engineering charges will be appreciably reduced. The author hopes to obtain test data for this conversion prior to the discussion of this paper.

Engineering and Bulk Grain Costs.—Cost for the floating pneumatic elevators apart from establishment and other special charges may be regarded as being made up of engineering and bulk grain costs. Engineering costs refer to the working and maintenance of the machines themselves and the engine-room crew therefor, and will be found set out in Table II. Bulk grain charges are for extra labour employed on or about the machines in connection with the actual discharge of grain, and include such items as wages for grain superintendents and their staffs, foremen, ship workers, deck crews, gangs in the ship's hold and aboard the elevator itself, weighers for operating the scales, &c.

From the table it will be noted that the Group C or new machines show to advantage in the matter of engineering costs.

Test Results and Remarks Thereon.—Certain "chute loose" tests on Group C machines are set out in the Table III. of Tests. In considering these results, it should be noted that they are not a measure of the maximum rate at which the intake or pneumatic portion of the machine would lift grain; but only of the limited rate at which weighers deliver it to craft; and further that any delays caused by faulty operation of the grain-pipes in the ship's hold, or the craft receiving delivery are included therein. The rates of discharge given in the Table II. of Costs have been reproduced in Table III. to show that these and similar delays have a very appreciable effect on the performance of the machine.

Conclusion.—It has not been possible to refer to the operation of the plant as a whole and more particularly the rotary exhauster portion thereof when actually working grain; this matter will no doubt arise in any discussion which there may be on the paper. The author wishes to record his thanks to Mr. C. R. S. Kirkpatrick, chief engineer to the Port of London Authority, for permission to publish the figures given; and to Brigadier-General M. Mowat, the Institution's Secretary, for assistance in the preparation of the paper.

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CONVEYING AND ELEVATING MACHINERY.*

By GARDINER MITCHELL, of Aberdeen, *Member.*

THE problem of handling material by mechanical means is a very great one, and the handling of materials, whether raw or finished products, has become a prominent and dominating factor in the problem of economical production, especially in these times when cost of labour is so high. Within the past thirty years various methods of handling materials have been devised to meet conditions arising from time to time, these methods culminating to-day in a specialisation embodying design and construction, equal to, if not surpassing, many developments in other branches of mechanical science. Practically all material, in bulk or packages, may be handled by machinery employing any of the many types of conveyors of elevators which may be suitable for the class of material to be handled.

CONVEYORS.

In the strictly technical sense a conveyor is a machine carrying material continuously in a constant stream from its receiving end to the delivery point or points. Conveying machinery may be divided into approximately nine distinct classes, namely: spiral, screw, paddle, belt, gravity bucket, tray, slat, push-plate or scraper, and drag-link, each type being specially suitable for dealing with certain kinds of material.

(1) *Spiral or Worm.*—The spiral or worm conveyor consists of a sheet steel trough, Fig. 1 (page 867), having end bearings, and intermediate bearings are fitted at about 7-ft. pitch. On the shaft is mounted the spiral or worm, made of flat bars, angles, or tees, connected to the shaft with arms. The same type of conveyor can be fitted in cast-iron troughing, generally in 7-ft. lengths, having flanges at ends for bolting together.

(2) *Archimedean Screw.*—The archimedean screw conveyor has a trough similar to the spiral type. The blades are of steel plates pressed into the shape of a helix close fitting to shaft. The blades may also be made of cast iron, in sections, usually mounted on a square shaft. The foregoing types of conveyors are made in sizes from 6 in. to 36 in. capable of dealing with 4 to 100 tons of material per hour.

(3) *Paddle Conveyors.*—Paddle conveyors are similar in construction to the spiral, excepting that on the shaft are fitted fan-shaped blades or paddles. The capacities of screw, spiral, and paddle conveyors can be calculated by the formulæ given. The table in Appendix I. (page 869) may be considered standard details of conveyor, from 6 in. upwards. The output is calculated on material weighing 50 lb. per cubic foot. The type of conveyors

* Paper read before the Institution of Mechanical Engineers, Friday, December 16, 1921.

diameter, and speed, affects the horse-power calculation to only a very small degree, and therefore need not be taken into account. The horse-power required to drive conveyors is equal to the weight of material to be handled in tons per hour multiplied by length of conveyor in feet by a constant depending on the class of material to be handled.

(4) *Belt-Conveyors.*—At the present day hundreds of thousands of installations of belt-conveyors are at work on almost all kinds of material. A belt conveyor may be described as an endless belt running over a drum at each end of the framework, with intermediate supporting rollers for both the top and bottom runs of belt, Fig. 2. The driving end is the simplest possible. It consists of a terminal drum or pulley (A) keyed to a shaft (B) which is mounted on two bearings (C) on the end framework, Fig. 3. The tightening end or terminal at the other end is somewhat similar, the drum is secured to a shaft which is carried in two sliding bearings. There are in use several designs of automatic tension gear or take-ups, having balance weights to compensate the weight of the belt and maintain a tension on it: this should not exceed 15 to 20 lb. per inch ply. Steel channels extend the whole length of the conveyor with cross channels about 5 ft. pitch to carry the top curving roller sets. Cross channels may be fitted about 25 ft. pitch to support the top edge guide rollers; the bearings of the bottom or return rollers are bolted to the longitudinal channels and are pitched about 12 to 15 ft.

Top Carrying Rollers.—These are of three types: (a) the flat type; (b) two-roller type where conveyors do not exceed 18 in. width; (c) the more universal type which consists of two inclined side rollers and centre horizontal roller or rollers. In Fig. 4 one or more cast-iron rollers (A) are arranged to run on an horizontal tube spindle (B) which is a fixture in two brackets,

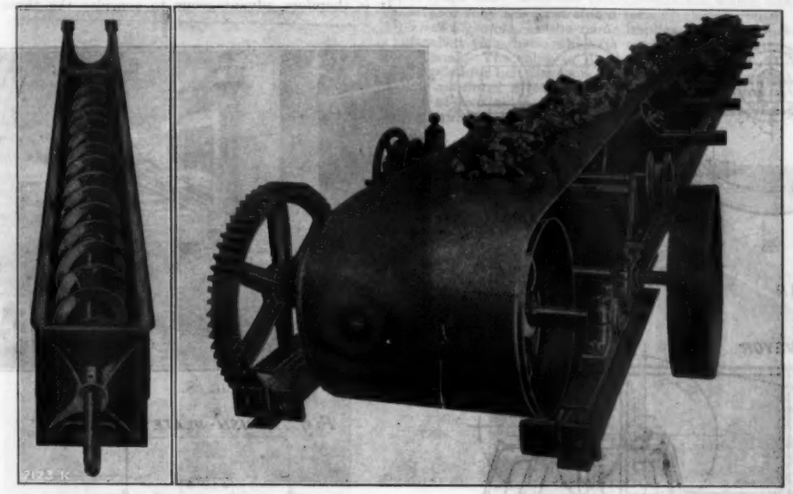


FIG. 1.

FIG. 3.

Fig. 2. GENERAL ARRANGEMENT OF BELT CONVEYOR

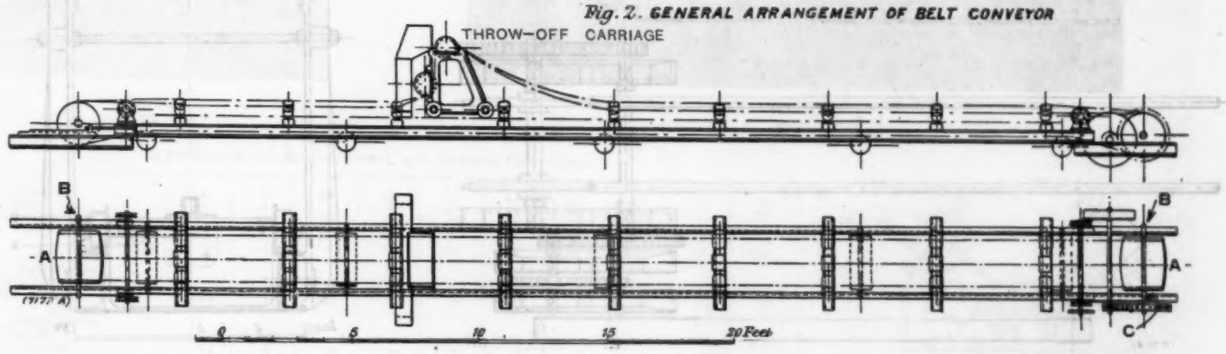


Fig. 4. CROSS SECTION

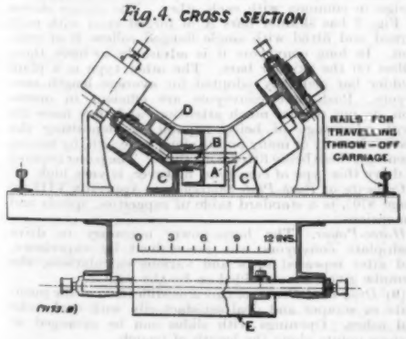
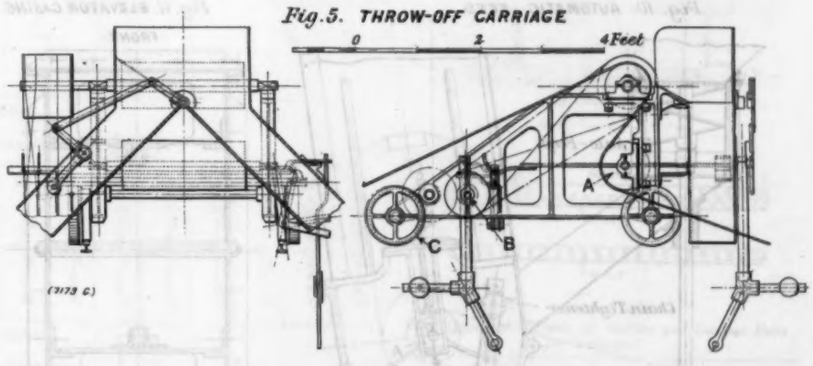


Fig. 5. THROW-OFF CARRIAGE



Bottom Carrying Rollers.—Fig. 4 illustrates one type where the roller is constructed with a steel tube (E), the diameter of which depends on the width of the belt. In Appendix II (pages 869) a diagrammatic cross-section of a belt-conveyor is given. Also a table of standard dimensions of the various rollers and spindles suitable for belt conveyors from 12 to 48 in. in width.

Belts.—The conveyor belt is considered to be the most vital part of any belt-conveying plant, and it is advisable to instal a first-class belt; although the initial cost is much greater than many of the inferior classes, the best is the greatest economy. For all material with sharp cutting edged, a rubber and canvas belt should be used. The details given in Appendix III (page 869), may be considered standard practice. The stepped type of belt A is strongly recommended as most suitable for all conveyors having troughing rollers, the belt being specially flexible to form the trough, also the extra thickness of rubber in the centre ensures long life. Where a rubber and canvas belt is used for handling grain or any like material, a much lighter class is suitable. Solid woven cotton canvas belting is made up to 60 in. wide and in thicknesses ranging from $\frac{1}{4}$ in. to $\frac{1}{2}$ in., and this type is used for a variety of purposes. Observations have been made of the wear which takes place in belting; rubber and canvas belting was found to be the most efficient, balata next, the wear of which is about four times greater; then in solid woven canvas the wear was about five to six times greater than what took place on rubber and canvas, and with sewn cotton duck canvas the wear was about seven times greater than rubber and canvas.

Belt Tension.—It has already been stated that belt tension should not exceed 20 lb. per inch per ply, which may be calculated by formulæ. A belt-conveyor can be run successfully at an angle which should not exceed 20 deg., except in the case where the material is not liable to roll back or the belt is fitted with cross or vee shaped leather bars copper riveted on, in which cases the conveyor may operate successfully at angles of 25 to 30 deg.

Throw-off Carriage.—Belt conveyors designed to handle material from feed point or points to one fixed delivery point, may or may not have a shoot at delivery end. If, however, it is necessary to deposit the material at various points along the length of conveyor, such as feeding into various storage hoppers, then a throw-off carriage must be introduced (see Fig. 2 below). Fig. 5 is a drawing of one type of throw-off carriage; it is self-propelled, driven by open and cross belt from the shaft of drum A on to shaft B, and, by gearing, drives the travelling wheels C. The capacity of belt-conveyors can be calculated by the formulæ given, and the horse-power required to drive this class of conveyor can be got from the HP formulæ. The power required to drive belt-conveyors is very small; this type is considered to be the most economical as regards power.

Appendix IV (page 869) is a table of standardised particulars of belt-conveyors, compiled by the author.

(5) *Gravity Bucket-Conveyor.*—This conveyor is practically the only type which can deal successfully with gritty or hot materials. It may be described as two lines of chain parallel to each other with projecting pins or axles having suspended buckets, these being maintained in an horizontal position by the action of gravity, whatever the position the line of chains is in. Buckets are made in three different ways: (1) A malleable castings which withstands the wear of gritty material; (2) stamped steel, hydraulically or toggle pressed from one sheet; and (3) made of steel plates cut to shape and joined together with corner angles, Fig. 16, Appendix V (page 870). To provide for tipping or dumping the buckets, there are two methods: (1) A tilting pin (malleable casting) A, Fig. 6 may be riveted on each side of the bucket; and (2) by a malleable cast-iron cam riveted on each side of the buckets. Cast-iron or malleable cast-iron support bosses or brackets B, are bolted or riveted to the sides of buckets having a recess

into which the bucket supporting axle which projects from the chain, is accommodated.

Chains are usually made of steel links with steel pins and to dimensions in the table and Fig. 17, Appendix VI (page 870), and the rollers are of cast-iron single flanged, the diameter on tread being about 1¼ in. greater than the width of chain link.

The *Driving Gear* may be either of two types—one having sprocket wheels and shafts and gears, Fig. 7. Another type has a cam and pawl-actuated mechanism.

Regarding tipping gear, or apparatus, there are two principal types, pin gear (see Fig. 6) and the cam gear. Either of these gears may be fixed in predetermined positions, or can be arranged to travel on angles or rails with locking gear to fix at the required point.

Revolving Filler.—There are a few types of fillers, which may be stationary or travelling. By adopting a filler, spilling is prevented and an equal supply of material is given to each bucket.

Capacity and Speed.—The capacity of gravity bucket-conveyors ranges from 10 to 150 tons per hour, with speeds from 30 to 40 ft. per minute according to the class of material being dealt with, the table in Appendix VII (page 870) however gives average results, the calculations being based on material weighing 50 lb. per cubic foot and of a dry nature. The power necessary to drive a gravity bucket-conveyor is found to be remarkably small.

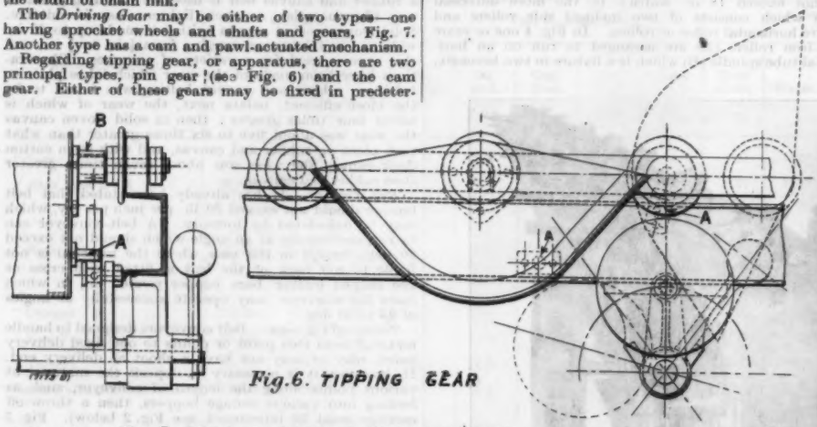
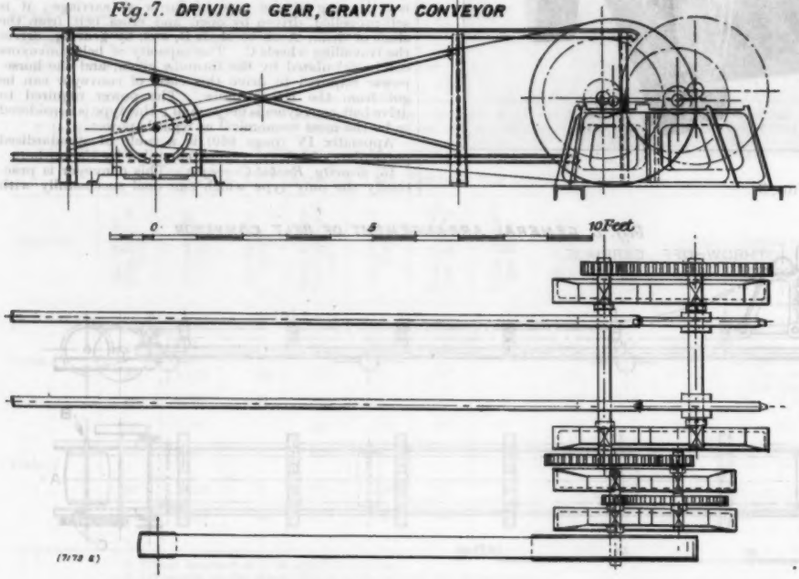


Fig. 6. TIPPING GEAR

Fig. 7. DRIVING GEAR, GRAVITY CONVEYOR



Tray (6) *and Slat* (7) *Conveyors* may be classed together, as both have characteristics in common, inasmuch as they are capable of discharging only over the end and not at intermediate points, excepting however in a tray conveyor, a plough can be fitted to plough or divert the material to one side into shoot; again a vee-shaped plough will divert the material to both sides. The purposes for which tray and slat conveyors can be installed in works, warehouses, &c., are so numerous that it is hardly possible to mention any material they will not handle; they are very suitable where it is desired to feed the material on to the conveyor once only, and it is not to be touched till it is deposited at the end; Fig. 8 shows a slat conveyor for sacks.

Capacity.—So much depends on the type of tray conveyor under consideration, that it is not a simple matter to construct a formula for capacities. The table given may, however, be considered a good average based on a tray speed of 70 ft. per minute.

(8) *Push-Plate Conveyors* are sometimes termed scraper conveyors, and are closely allied to drag link conveyors. It is therefore advantageous to consider the three at

FIG. 8.

Fig. 9. PUSH-PLATE CONVEYOR

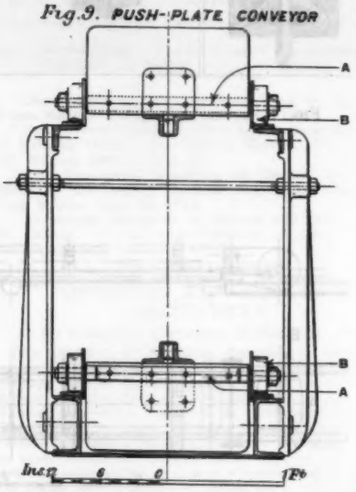


Fig. 10. AUTOMATIC FEED

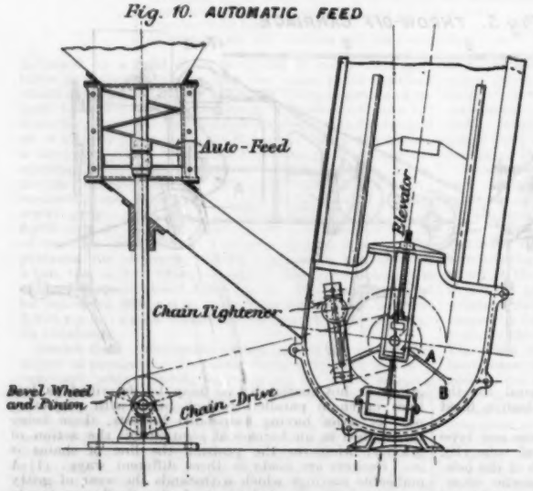
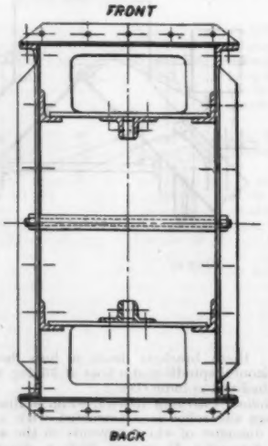


Fig. 11. ELEVATOR CASING



the same time, as they have many functions and parts of design in common with each other. The design shown in Fig. 9 has skidder bars A of forged steel with ends turned and fitted with single flanged rollers B of cast-iron. In long conveyors it is advisable to have these rollers on the skidder bars. The other type is a plain skidder bar generally adopted for average length conveyors. Push-plate conveyors are efficient in operation, do not require much attention, and they have the great advantage of being capable of depositing the material at any or many points along its length, by having openings, these being fitted with slides. The power required to drive this type of conveyor, however, is very high.

Capacity of Push-Plate Conveyors.—Appendix VIII (*a*) (page 870), is a standard table of capacities, speeds and dimensions.

Horse-Power.—The horse-power necessary to drive push-plate conveyors was ascertained by experience, and after repeated tests and various calculations, the formulæ given were decided on by the author.

(9) *Drag-Link Conveyors* are a modification of the push-plate or scraper and deal satisfactorily with coal, coke and ashes. Openings with slides can be arranged at various points along the length of trough.

ELEVATORS.

An elevator is an appliance for lifting or handling material from one level to another, this need not necessarily be vertically, as the elevator can be at any angle to suit requirements. There are various designs of elevators, each having certain essential features by which they are peculiarly suited to handling many different kinds of material. The designs usually adopted are: (1) Steel cased chain elevator; (2) lattice framed chain elevator; (3) steel cased belt elevator; (4) lattice framed belt elevator; (5) wood-cased belt elevator; and (6) continuous bucket elevator.

Elevators comprise endless chain or chains, belt or belts, passing over end-sprockets or drums, one being at the bottom and the other at the top, which is somewhat near where it is necessary to deposit the material. To the chain or belt are attached the buckets at a fixed

pitch. In the usual design of boot or bottom fittings, there are two sides A of cast-iron having slots, Fig. 10. In these slots are fitted sliding bearings B, having tension screws so that the slack of the chain or belt can be taken up. At the head of the elevator the shaft is carried by two bearings bolted to angles on the elevator casing; on the shaft is keyed the chain wheel or belt drum, and if the elevator is a short one, a belt pulley would be keyed to the end of the shaft to receive the drive. Where it is a long elevator, a spur-wheel and pinion are fitted with countershaft and bearings, and the pulley receiving the drive is keyed to countershaft.

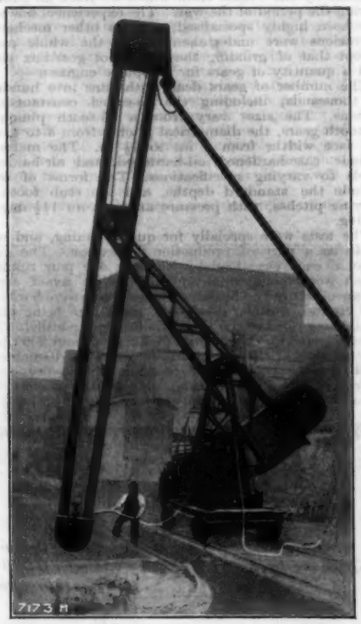


FIG. 12.

The standard design of steel casing is given in cross-section, Fig. 11, and is constructed with steel plates on the four sides. Lattice framing consists of four guide-angles with back trough plate and tees on sides having cross stay-bolts as in the former.

Chains.—There are many types used for both conveyor and elevator work, namely, mild steel, malleable cast iron, cast steel and manganese steel, all to suit various duties. The table in Appendix VIII (*b*) (page 870) gives standard mild steel chains for different sizes of elevators. The malleable cast-iron chains most universally adopted for elevators are found in Appendix IX (*a*) (page 870), with the recommendation which size of elevator they are most suited for.

Belt Elevators, as the name implies, have the buckets attached to a belt, which is made of several kinds of material. The table in Appendix IX (*b*) (page 870) is compiled for belt elevators from 6-in. to 24-in. buckets.

Wood-Cased Elevators are made with the casing in one box of four sides, or it may be two legs each for a belt or chain and buckets.

Buckets are made usually of stamped steel practically of all sizes and of various shapes. Appendix X (*a*) (page 870) gives tabulated dimensions of bucket and chain elevators 6 to 24 in. These are standard particulars of chain speeds, shaft speeds, chain wheels, gearing, pulleys and capacity of elevators. Appendix X (*b*) gives standard details of belt elevators 4 to 12 in. In calculating the capacity of an elevator, consideration must be given to whether the elevator is vertical or inclined, and the capacity of each bucket allowed for accordingly. The horse-power formulæ given have been tested against numerous plants in operation and found to be reliable.

Fig. 10 shows a section of a screw-feed which gives most satisfactory results. This design has been the result of long and careful study of the problem and the carrying out of exhaustive experiments. Fig. 12 is reproduced from a photograph of barge elevator.

Stoking elevators and conveyors form a type of plant giving excellent labour-saving results, Fig. 13. A feature of this plant is the automatic belt shifting device which operates when the hoppers are full.

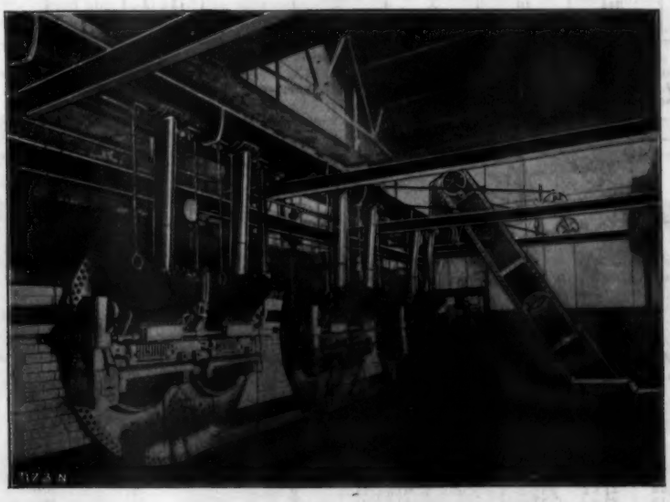


FIG. 13.

APPENDIX I.—SCREW, SPIRAL AND PADDLE CONVEYORS.

Diameter of spiral	6	8	10	12	15	18	21	24	30	36
Pitch of spiral	5	6	7	8	10	11	12	14	17	20
Pitch of fasteners	12	14	16	17	17	18	19	21	25	30
Speed r.p.m.	80	70	60	55	50	45	40	35	30	25
Output tons per hour	3	5	8	12	20	30	40	53	88	125
Light Pattern.										
Section of spiral	1 × 3/16	1¼ × ¼	1¼ × 3/16	1¼ × 3/16	1¼ × 3/16	2 × ⅜	2 × ⅜	2¼ × ⅜	2¼ × ⅜	3 × ¼
Tube shaft bearings	1¼	1¼	2	2	2¼	2¼	2¼	2¼	3¼	3¼
Heavy Pattern.										
Section of spiral	1¼ × ¼	1¼ × 3/16	1¼ × ⅜	1¼ × ⅜	2 × ⅜	2¼ × ¼	2¼ × ¼	2¼ × ¼	3 × ¼	3¼ × ¼
Solid shaft bearings	1¼	2	2¼	2¼	2¼	2¼	3	3	3¼	4
Archimedean Screw.										
Blades	3/16	¼	3/16	3/16	3/16	3/16	¼	¼	3/16	3/16
Shaft	1¼	2	2¼	2¼	2¼	2¼	3	3	3¼	3¼
Paddle Type.										
Tube shafts	1¼	1¼	2	2	2¼	2¼	2¼	2¼	—	—

All dimensions are in inches.

APPENDIX II.—BELT-CONVEYOR ROLLER SETS (SEE FIG. 14.)

Width	12	15	18	21	24	27	30	36	40	44	48
Top rollers, diameter A	5	5	6	6	6	7	7	7	8	8	9
,, width B	4	5	5½	6	7½	8½	9	10½	10½	10½	10½
,, tube spindles C	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	2
Bottom rollers, diameter D	4	4	5	5	5	6	6	7	7	8	8
,, width E	14	17	20	23	27	30	32	38	42	47	51
,, solid spindle F	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	2	2
Top edge guides, diameter G	4	4	4	5	5	5	5	6	6	6	6
,, ,, width H	3	3	4	4	4	5	5	5	5	6	6
,, ,, tube spindles J	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼

All dimensions are in inches.

APPENDIX IV.—BELT-CONVEYORS.

Width	12	15	18	21	24	27	30	36	40	44	48
Driving end drum	18	20	22	24	27	30	33	36	38	40	42
Tension end drum	15	18	20	22	24	26	28	30	32	34	36
Width of both above	14	17	20	23	27	30	32	38	42	47	51
Gearing ratio	3 : 1	3 : 1	4 : 1	4 : 1	4 : 1	5 : 1	5 : 1	5 : 1	6 : 1	6 : 1	6 : 1
Pitch	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼
Driving pulley	18×4	18×5	21×4	21×5	24×5	24×5	30×5	30×6	36×6	36×8	42×8
Speed	128	150	208	192	170	222	203	212	240	288	273
Output tons per hour	30	48	70	82	95	123	136	187	206	281	312
Speed feet per min.	200	250	300	300	300	350	350	400	400	500	500
Rubber and canvas belt, ply	3	3	4	4	5	5	5	6	6	7	7
Solid woven canvas belt, thickness	3/16	3/16	¼	¼	¼	3/16	3/16	¼	¼	¼	¼
Size of longitudinal channels	5×2½	5×2½	5×2½	6×3	6×3	6×3	7×3½	7×3½	7×3½	8×3½	8×3½

All dimensions in inches. Calculations for horizontal conveyors 100 ft. centres.
Output calculated on material 50 lb. per cub. foot.

Fig. 14.

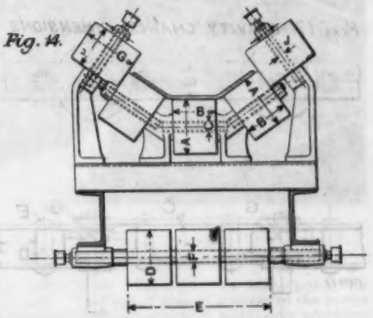
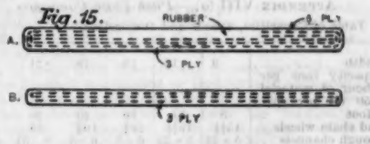


Fig. 15.



APPENDIX III.—*Table of Rubber and Canvas Belts for Conveyors.*

Width.	Plies.		
	Stepped.		Ordinary.
	Centre.	Edges.	Equal Plies.
Not exceeding—			
12 inches	2	4	3
18 ,,	3	5	4
24 ,,	3	6	5
30 ,,	4	6	5
40 ,,	5	7	6
48 ,,	6	8	7
	See sketch A, Fig. 15.		See sketch B, Fig. 15.

CONVEYING AND ELEVATING MACHINERY.

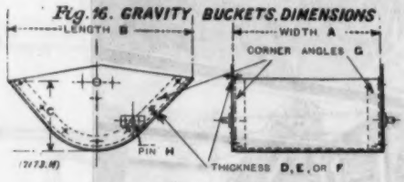
(*For Description, see Page* 866).

APPENDIX V.—SEE FIG. 16.

A	B	C	D	E	F	G	H	J
Width.	Length.	Depth.	Mall. cast thickness.	Stamped steel thickness.	Built up Steel thickness Plates.	Corner angles for F.	Tilting Pin.	Pitch of Chain.
10	16½	7	¼	¼	¼	1½ × 1½ × ¼	¾	9
12	16½	7	¼	¼	¼	1½ × 1½ × ¼	¾	9
15	16½	8	¼	¼	¼	1½ × 1½ × ¼	¾	9
18	22½	8	¼	¼	¼	1½ × 1½ × ¼	¾	12
21	22½	8	¼	¼	¼	1½ × 1½ × ¼	¾	12
24	22½	9	¼	¼	¼	1½ × 1½ × ¼	1	12
27	28½	9	¼	¼	¼	1½ × 1½ × ¼	1	15
30	28½	10	¼	¼	¼	1½ × 1½ × ¼	1	15
33	34½	10	¼	¼	¼	1½ × 1½ × ¼	1	18
36	34½	10	¼	¼	¼	1½ × 1½ × ¼	1	18

All dimensions are in inches.

Fig. 16. GRAVITY BUCKETS. DIMENSIONS.

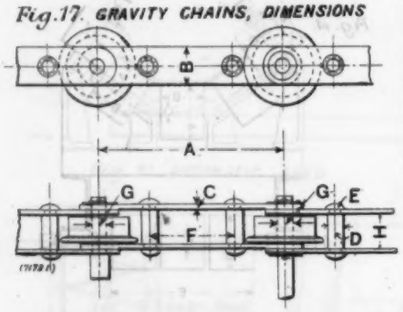


APPENDIX VI.—*Gravity Bucket-Conveyor Chains (see Fig.* 17.)

Width of Conveyor-bucket.	Pitch of chain A.	Section of Link B × C.	Driving Studs. D.	Driving Studs. E.	Pitch of studs F.	Pin Diam. G.	H.
10	9	2 × ¼	½	½	3½	½	2½
12	9	2½ × ¼	1	½	3½	1	2½
15	9	2½ × ⅜	1	½	3½	1	2½
18	12	2½ × ⅜	1	½	5	1½	2½
21	12	2½ × ½	1½	½	5	1½	2½
24	12	2½ × ½	1½	½	5	1½	2½
27	15	2½ × ⅜	1½	1	7	1½	2½
30	15	2½ × ⅜	1½	1	7	1½	2½
33	18	3 × ⅜	1½	1½	7	1½	2½
36	18	3 × ⅜	1½	1½	7	1½	2½

All dimensions are in inches.

Fig. 17. GRAVITY CHAINS, DIMENSIONS.



APPENDIX VIII (*a*).—*Push-Plate Conveyors.*

Table of Capacities, Speeds and Dimensions.

Width	9	12	15	18	21	24
Capacity tons per hour of material 50 lb. per cub. foot	8	11	16	20	30	40
End chain wheels	15½	15½	19½	19½	24	24
Trough channels	5 × 2½	5 × 2½	6 × 3	6 × 3	8 × 3½	9 × 3½
Speed, ft. per min.	80	75	75	75	70	70

APPENDIX VIII (*b*).—*Standard Dimensions of Elevator Chains and Skidder Bars.*

Size.	Pitch.	Solid link.	Angle link.	Side link.	Skidder bars.	Bolts fixing Buckets.	Joint Rivet.
6	6	1 × ⅜	1½	¼	1½ × ¼	½	½
8	6	1½ × 1	1½	¼	2 × ¼	½	½
10	6	1½ × 1	1½	¼	2 × ¼	½	½
12	6	2 × 1	2½	¼	2½ × ¼	½	½
15	9	2 × 1	2½	¼	2½ × ¼	½	½
18	9	2 × 1	2½	¼	2½ × ¼	½	½
21	12	2½ × 1½	2½	½	3 × ½	½	1
24	12	2½ × 1½	2½	½	3 × ½	½	1

All dimensions are in inches.

APPENDIX VII.—*Gravity Bucket-Conveyors. Capacity and Speed.*

Width in inches.	Capacity.	Speed.
	Tons per hour.	Feet per minute.
10	14	40
12	16	40
15	22	40
18	34	40
21	40	40
24	40	30
27	56	30
30	70	30
33	90	30
36	100	30

APPENDIX IX (*a*).—*Table of Malleable Cast Chains Suitable for Elevators.*

Size inches.	No.	Pitch.	Working strain.	Belt they are equal to.
			lb.	
3 & 4	45	1⅞	400	3 inches
6	57	2½	650	6 ,,
8	67	2½	800	9 ,,
10	78	2½	800	10 ,,
12	103	3	1,600	15 ,,
15	101	3½	1,800	18 ,,
18	503	3	3,000	18 double
21	600	6	4,000	24 ,,
24	600	6	4,000	24 ,,

APPENDIX IX (*b*).—*Belt Elevators 6-24 In. with Thicknesses of Belts Recommended.*

Width of Bucket.	Rubber and canvas.	Balata.	Sewn canvas.	Solid Woven thickness.	Leather.
Inches.	Ply.	Ply.	Ply.	Inch.	Inch.
6	3	3	4	⅛	¼
8	3	3	5	⅛	⅛
10	4	4	5	¼	⅛
12	4	4	6	¼	¼
15	5	5	6	¼	¼
18	5	5	7	¼	¼
21	6	6	7	⅛	⅛
24	6	6	7	⅛	⅛

APPENDIX X (*a*).—*Bucket and Chain Elevators.*

Width of buckets	6	8	10	12	15	18	21	24
Speed ft. per min.	144	130	125	110	100	90	84	84
Top tumbler diam.	15½	15½	19½	19½	19½	24	24	24
Gearing ratio	3 : 1	4 : 1	4 : 1	4 : 1	4·5 : 1	4·5 : 1	5 : 1	5 : 1
Pitch	¾	1	1¼	1¼	1¼	1½	1½	2
Countershaft r.p.m.	108	130	100	88	90	67·5	70	70
Belt pulley	20 × 4	24 × 4	30 × 5	30 × 6	36 × 6	36 × 7	40 × 7	42 × 8
Output tons per hr.	3	5	8	10	13	20	28	32
Top shaft r.p.m.	36	32·5	25	22	20	15	14	14

All dimensions are in inches.
Calculated on elevators 50 ft. centres.
Output calculated on material weighing 50 lb. per cub. ft.
Buckets 24-in. pitch.

APPENDIX X (*b*).—*Belt Elevators.*

Width of buckets	4	5	6	8	10	12
Speed ft. per min.	200	190	180	168	158	147
Top drums	12	12	16	16	20	20
Bottom drums	10	10	13	13	16	16
Top shaft r.p.m.	64	60	43	40	30	28
Output, tons per hour	2¼	3¼	6	8	12	27

All dimensions are in inches.
Output calculated on material 35 lb. per cub. ft.
Buckets at 18-in. pitch.

NOTES ON MOTOR CAR GEAR-BOXES.*

By H. F. L. ORCUTT.

(*Continued from page* 831.)

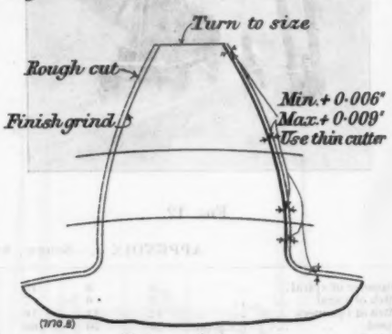
SPECIAL GEAR TESTS.

IT is hoped that it will be of interest to members to have laid before them the conclusions drawn from some tests made on gear-box gears extending over a period of nine years in connection with the development of a special process of finish-grinding the teeth of hardened gears. The work connected with these tests has, of course, been much interrupted, diverted, and made difficult by the events from which we have all suffered during the period of the war. The experience, however, has been highly specialised, and no other mechanical operations were undertaken during the whole period except that of grinding the splines of gear-box shafts and a quantity of gears for aeroplane engines.

The number of gears dealt with runs into hundreds of thousands, including the so-called constant-mesh pinions. The sizes vary from a 15-tooth pinion to 60-tooth gears, the diametrical pitches from 8 to 4, and the face widths from ⅜ in. to 1½ in. The materials include case-hardened, oil-hardened, and air-hardened steels to varying specifications. The forms of teeth include the standard depths, and the stub tooth of varying pitches, with pressure angles from 14½ deg. to 25 deg.

The tests were specially for quiet running, and were made as a part of production inspection. The gears were in each case tested with only one pair running, which were mounted on spindles set to exact centre distance, secured on bushes or plugs which were hardened and ground, running dead true, great care being taken in all cases to have the two spindles dead parallel. The speed selected for the driving spindle was about 900 r.p.m. The spindles of the testing fixture are 4 in. diameter, of good length, running in bearings with very small clearances, all fittings being made with special care. The driving belt is 4½ in. in width. A band brake, 3 in.

Fig. 2. STOCK REQUIRED FOR TOOTH-GRINDING.



Bottom of Space from 0·000" to 0·010" Stock.

Standard Involute Form. Any Pressure Angle.

wide, was applied to the driven spindle. The gears under test were run dry as well as lubricated by splashing with thin oil. The fixture itself ran without noise, and there can be no question but that any noise produced by these tests was purely a gear-tooth noise. Many of the tests have been made in direct comparison on the same fixture under identical conditions, with gears finished as accurately as possible before hardening.

The results of these tests can be briefly stated. The gears were made to run in all cases so quietly that if the same results could be secured in a gear-box it would be called noiseless on all speeds. Some of these gears ran remarkably quietly in boxes, but in very few boxes were they perfectly silent under running conditions on the road. In nearly every case they were more quiet than unground gears under load in the road test. In some cases the gears with perfectly accurately ground teeth are apparently just as noisy in the box as gears unground. In this comparison, however, the unground gears have always been subjected to special selection, stoning and very costly hand work on the teeth.

The conclusions submitted are as follows :—

1. That gear-box gears which are hardened after finishing are always noisy.

2. That gears with teeth accurately finished after hardening are quiet.

3. That gears with teeth finished as accurately as possible may be noisy in the best finished gear-boxes.

4. That gears with teeth roughly finished may be under some conditions comparatively quiet.

5. That the accurately finished gear is just as essential to cheap and uniform production as the accurately finished cylindrical shaft or bearing.

6. That in a quiet running pair of gears the limits of accuracy on the teeth are the finest possible, much finer than are required in any other conjugate surfaces in the gear-box.

7. That in the ordinary gear-box the gear teeth are usually the least accurate of any of the working surfaces.

8. That thorough development in gear-box design will

* Paper read before the Institution of Automobile Engineers, December 15, 1921.

not be possible unless all parts, including gear teeth, are of accurate finish within known limits.

9. That some ratios run more quietly than others, tooth load and quality of finish being equal.

10. That the stub gear to run quietly must have extreme accuracy in tooth form, especially in pitch spacing. Consequently this gear is more difficult to finish to a degree of quiet running than the full depth tooth gear.

The tests recorded and the production work connected with them, have demonstrated conclusively two things which are important to the motor car engineer. First, that in a gear giving the service required in the ordinary gear-box, if it is expected to run quietly, a perfection of tooth contact is necessary which it is hardly possible to secure by any of the ordinary gear-cutting methods. Second, that in the usual motor car gear, if it is hardened after the teeth are finished, the perfection of tooth contact necessary to quiet running is not possible. Further, in a gear with the teeth hardened after finishing, the full possible tooth-wearing surfaces do not exist.

Unless these details are given full recognition, it is safe to predict that substantial progress in gear-box improvements will not be made, improvements which are desirable to put this unit in line with other parts of the motor car, and which, sooner or later, will be demanded by the public.

Much research work is necessary to determine minimum of the mysteries of gear-tooth action still have to be solved. Some of the uncertainties have been cleared up in the development work which has been carried out in connection with the process to be described.

Gear-tooth grinding takes the place of the usual finishing cut on the milling, hobbing or generating machine. The cutting tool is an abrasive wheel correctly shaped to grind out the tooth space after the gear is hardened. The stock left for finish-grinding the teeth of the usual motor car gear should be enough to allow for the removal of all hardening distortions and such inaccuracies as may occur when the roughing cuts are reduced to the lowest cost. The teeth are finish-ground as a last operation with the gear truly mounted on bushes or mandrel which exactly fit the hole in the gear. The operations on a motor car gear are as follows :—

Operation 1. Bore and turn.
Operation 2. Broach.
Operation 3. Rough mill teeth.
Operation 4. Round teeth.
Operation 5. Harden or heat-treat gear.
Operation 6. Sand blast.
Operation 7. Grind hole to finished size, registering the hole from the bottom of the splines.
Operation 8. Grind the ends of the hubs of the gear.
Operation 9. Finish-grind the teeth.

In Fig. 2 details are given of stock to be left on the a larger original, so that any errors are reduced to an infinitesimal amount in the finished gear teeth. The machine is provided throughout with adjustments to take up the wear of working surfaces and of the diamonds themselves, so that corrections of form are quickly made.

It will be seen that the process differs radically from any other form of tooth cutting. The outstanding feature is the principle by which the tooth form is controlled or altered in the machine in which the gear is finished. The tooth form is not dependent on a generating mechanism nor on the shape of a cutter, both of which are more or less unalterable. For each gear an original form is made with the correct involute called for by the pitch, number of teeth and pressure angle. When there is theoretical interference, forms are modified to give correct tooth contact.

The process described as made use of to-day is the result of about ten years' work. This work includes many experiments with various mechanical devices, designing of machines and trials of various methods of working and testing. It has been accompanied from the beginning by investigations in tooth forms, with the object of producing a quiet gear. Quiet running has always been the final test by which the quality of the finished gear was determined. As a result of this experience, a number of statements which it is believed are important can be made respecting gear-tooth action

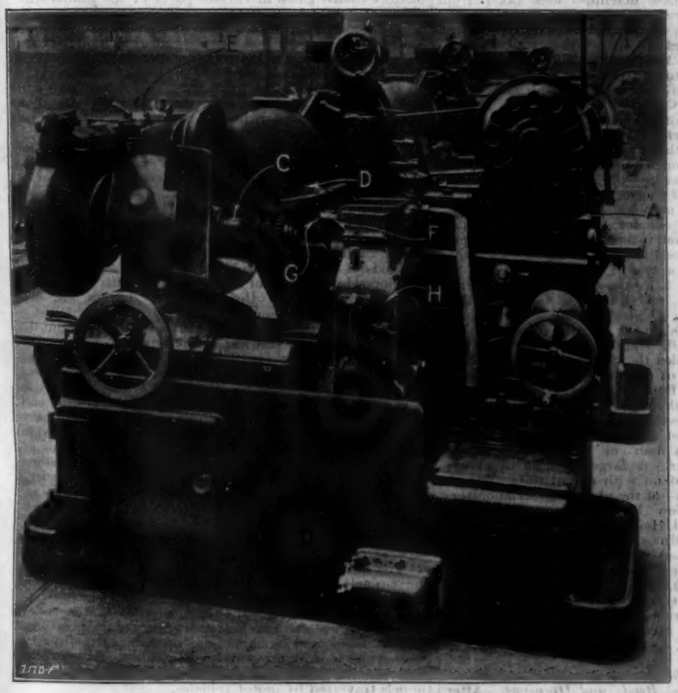


FIG. 3.

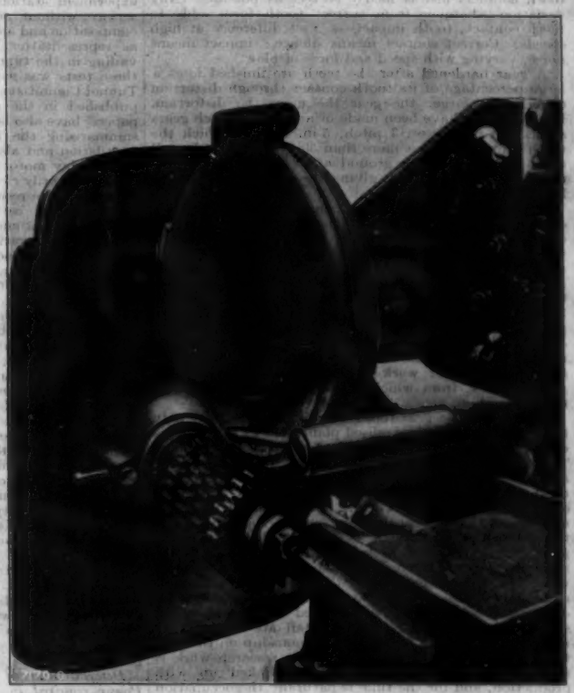


FIG. 4.

areas and sections of straight spur-gear teeth which, accurately finished and properly mounted, will run quietly under maximum loads. The known qualities so far demonstrated by test and usage are, that heat-treated gears made of special material with comparatively small straight spur teeth will stand high peripheral speeds and heavy loads, and have long life. Further, that such gears are, at a moderate cost, materially improved in running qualities when the teeth are accurately finished after they are hardened.

The following is an analysis of the sources of gear-box noises commonly observed :—

1. Inaccurately finished gear-teeth impacts.
2. Ball or roller bearing influences.
3. Influences outside the gear-box but which are manifest in the gear-box and come through either the front or rear connection.
4. The shape of the gear-box casing.
5. Weakness of the gear shafts and weakness of the casing.
6. The gear teeth being too small for the load.
7. Badly-mounted gears.
8. General bad workmanship in the box.
9. Periodic speeds in the engine.
10. Gear-box distortions caused by chassis movements.

THE GEAR-TOOTH GRINDING PROCESS.

The process of gear-tooth finishing to which reference has been made is an entirely new mechanical operation, and a short description will probably be of special interest to the automobile engineer. The subject of finishing gear teeth is such a large one that it can only be dealt with in the briefest possible manner. Some of our best mechanical engineers have devoted years to the problems of machining spur-gear teeth, and many gear teeth for finish-grinding. With these allowances rough cuts for the tooth spaces need be nothing more than a fast milling operation, and the highest possible distortions are allowed for.

The patent gear-tooth grinding machine is illustrated in Figs. 3 and 4 above. The illustration Fig. 3 shows the entire machine, while Fig. 4 is taken specially to show the grinding wheel, the trimming diamonds and the gears set for being ground. This machine is specially designed to deal with gear-box gears. It may be roughly described in its action as a combined grinding, gear-cutting and shaping machine. The abrasive wheel spindle is mounted on a reciprocating slide A, Fig. 3. This spindle is driven by a belt from the motor B, which is carried on the slide. The gears to be finished are mounted on a work arbour C, which is parallel with the wheel spindle slide. The revolving grinding wheel is passed successively through the tooth spaces of the gear. At the end of each stroke of the wheel slide the gear is indexed. After the gear is completely indexed it is fed upwards against the grinding wheel. This action is repeated until the tooth space is of the correct depth. This depth is controlled by dial readings at E. The wheel is kept to the correct form by two diamonds F, which are mounted dead central with the arbour holding the gears. As the wheel wears it is brought down to the diamonds for trimming and rigidly locked after each trimming operation. A third diamond G trues the top of the grinding wheel, which surface grinds out the bottom of the tooth spaces. The so-called trimming-box H is a special mechanism in which are mounted two original forms representing the two sides of the tooth space. These forms are much larger than the tooth itself, and control the path of the trimming diamonds through a pantograph mechanism, and themselves are made from and gear-tooth forms. They are now made public for the first time. They are of special interest to the motor car engineer and to others who have to consider problems of speed reduction through spur gearing.

The form of tooth made use of is a pure involute, with no modifications whatever. Experience shows that the approach to accuracy in tooth finish coincides with the approach to silence.

A pair of gears with theoretically correct teeth should run silently unless overloaded or inaccurately mounted. It is found by many tests that the ordinary motor car gear which is hardened after the teeth are finished, is never accurate. It may be fairly quiet under certain conditions, but is is never of uniform quality.

The gear with ground teeth can be produced in quantities with a higher degree of accuracy and uniformity than by any other method, for several reasons. Firstly, on account of the fact that the tooth-form is controlled in the machine in which the gears are ground. Secondly, the refinements of tooth-finishing called for in a high-class gear must be within such very fine limits that no other cutting tool but the grinding wheel is capable of producing these refinements (these refinements include tooth forms, tooth-positioning and tooth-spacing). Of course, in the case of the hardened gear there is no cutting tool except the grinding wheel that can be used to give a uniform finish to the teeth. Further, the process lends itself to methods of inspection which are quite useless applied to the products of ordinary tooth-cutting machines.

In respect to the high-duty spur gear the tooth-grinding process is specially important. By a high-duty gear is meant a gear which, with comparatively small tooth area, must carry a heavy load, run at high speeds, and have exceptional wearing qualities. Such a gear

calls for a combination of material with special physical properties, with a finish of tooth form to a high degree of accuracy. The physical properties are at present only obtainable by using material which may be heat-treated or hardened, and this material can only be finished by a grinding wheel. When this cutting tool is used to finish tooth surfaces the engineer has an unrestricted choice of material. He can specify physical properties which are impossible when the steel cutter is used as a tooth-finishing tool. The choice of material is important, as the action of mating gear teeth is at high speeds, under pressure, on a line only and always sliding. Under these conditions tooth abrasion will be rapid on any material if it does not have special physical properties.

Tests and actual running indicate that high peripheral speeds on straight spur gears can be adopted when they are made from high-grade material and with specially accurate teeth. It has been recorded that a peripheral speed of 10,000 ft. per minute is now being used on a certain service with satisfactory results. The maximum peripheral speeds usually recommended for straight spur gearing are not much over 2,000 ft. per minute. Even with moderately high speeds the number of tooth contacts per minute is enormous. A 60-tooth gear of 5 pitch, running at 1,000 r.p.m., would have a peripheral speed of about 3,000 ft., and 186,000 tooth contacts per minute. It is easy to understand that satisfactory running in such a gear could only be expected when the tooth contacts are as nearly correct as possible. Any variation whatever from correct tooth form adds to tooth contact, tooth impact—a vast difference at high speeds. Correct contact means silence; impact means noise, varying with speed and force of blow.

A gear hardened after the teeth are finished loses a large percentage of its tooth contact through distortion alone. The larger the gear the more the distortion. Measurements have been made of numbers of such gears about 2 ft. diameter, 3 pitch, 5-in. face, in which the tooth contact was not more than 50 per cent. of the full area. With the tooth ground after hardening the full tooth contact is secured, giving the gear a much longer life.

Beyond these general statements there are very few data available for high-duty spur gearing. What the engineer wants to know is the minimum tooth section which can with safety be adopted to carry a certain load at a specified speed, and the material from which the gear must be made. Tests with gears with inaccurate teeth cannot be conclusive, and reliable data cannot be compiled from such tests. It is claimed that a complete investigation of gear-tooth phenomena on straight spur gearing is impossible through any other process than one in which the abrasive wheel is used for tooth-finishing. Further work is now being undertaken on ground gears, from which records will be compiled as fast as possible.

At present the gear-tooth grinding process can only be made use of in a centralised plant, and to this there is on the part of some motor car makers an aversion. This aversion is perfectly natural and reasonable, and the attitude of the owners of the patents covering the gear tooth and splined shaft grinding machines should be explained. Ten years' work in production for the trade and in the development of the process has proved one thing which is not easy to understand, that is, that the plain spur gear, as used in the ordinary gear-box, will not run quietly unless the teeth are finished with refinements which cannot be maintained by the tooth-cutting methods commonly in use. These refinements are so extreme that even with the process now employed in gear grinding, special experience and a special staff are necessary to maintain a proper standard of workmanship on the gear teeth and the splined shaft. Further research work is necessary. This work is necessarily linked up with production, and for the time is naturally the occupation of a special staff and a specially organised equipment. The principle of working in a centralised plant has been accepted as the only one by which success could be assured in developing a new mechanical operation.

It is particularly interesting to note that the indispensable qualifications of a good high-duty gear and a good ball bearing are exactly comparable. Both must be made with a high degree of accuracy, with very fine limits of error and of specially selected and treated material. They must both be correctly mounted to give good running results. A large amount of educational and instructive work had been done in connection with ball bearings before its economies were understood. The same work must be done for the accurate gear before the full possibilities of the high service it will give are commonly accepted.

(To be continued.)

A High-Temperature Oil-Blast Flame.—In a paper recently presented to the Vienna Academy, "Mathematical and Physical Class," E. Hauser and E. Rie describe an oil gas burner, made for them by the Austrian Koerting Company, in which they claim to obtain a temperature of 3,000 deg. C., whilst the acetylene-oxygen blowpipe is not supposed to give more than 2,700 deg. C.

Coal Briquetting in Western Canada.—The province of Alberta in Western Canada possesses vast fields of high-grade lignite and sub-bituminous coals which, though excellent as fuels, are unsuitable for storage. It is, therefore, proposed to establish a briquetting industry at Edmonton, and estimates are being obtained for the initial plant, so that the money may be voted at the next session of the Provincial Legislature. Contractors who are interested in the manufacture of briquetting machinery should communicate with the Mines Department of the Alberta Government, at Edmonton.

BUREAU OF MINES EXPERIMENTAL TUNNEL FOR STUDYING THE REMOVAL OF AUTOMOBILE EXHAUST GAS.*

By A. C. Fieldner† and J. W. Paul.‡

In co-operation with the New York and New Jersey State Bridge and Tunnel Commissions, the Bureau of Mines has just completed the construction of an experimental tunnel in the Bureau's experimental mine at Bruceton, Pa., near Pittsburgh, Pa. The purpose of this tunnel is to make a final study of the ventilation problems arising from the adequate ventilation of vehicular tunnels for automobiles and trucks, especially the 9,000-ft. tubes that are being designed to handle the traffic between New York City and New Jersey under the Hudson River.

Chief engineer, Clifford M. Holland, of the Tunnel Commissions, has shown that there are three principal problems involved from planning the ventilation of this tunnel, namely: (1) The amount and composition of exhaust gases from motor vehicles; (2) the dilution necessary to render these exhaust gases harmless; (3) determination of coefficients of air flow and horse-power required in ducts, bends and openings.

Composition of Automobile Exhaust Gases.—The answer to the first problem was obtained by making road tests on 101 automobile and trucks at the Pittsburgh experiment station. These machines were taken from service without any previous adjustment so that the composition and amount of the exhaust gas may be taken as representative of actual operating conditions prevailing in the tunnel. A report covering the results of these tests was submitted to the chief engineer of the Tunnel Commissions, on November 1, 1920, and will be published in the report of the Commissions. Several papers§ have also been published in the technical journals summarising the important results as regards tunnel ventilation and also with reference to gasoline losses in present-day motor car operation due to the general use of unnecessarily rich mixtures.

In brief, the results of the road tests showed that the percentage of carbon monoxide (the poisonous constituent of automobile exhaust gases) for the various individual cars varied from 0·5 per cent. to 14 per cent.; passenger cars and speed trucks on level grades at 15 m.p.h. and 20 m.p.h. averaged 7 per cent., and 1½-ton to 5-ton trucks at 10 m.p.h. averaged 7·3 per cent. carbon monoxide.

Dilution Necessary to Render the Gases Harmless.—The information obtained in the solution of problem (1), in connection with a traffic count of the motor cars that will use the tunnel, enabled the tunnel engineers to calculate the total quantity of exhaust gases that would be evolved in the tunnel. Before calculation could be made on the amount of air that must be used in adequate ventilation, it was necessary to determine the largest proportion of the exhaust gases (more expecially carbon monoxide) in air that a man can breathe without any harmful effect whatever. A large amount of experimental work was carried on with actual tests—first on animals and then on men—at the physiological laboratory of Yale University, New Haven, Conn., under the direction of Dr. Yandell Henderson, consulting physiologist of the Bureau of Mines. It was found that when exhaust gases are diluted with fresh air to the point where the concentration of carbon monoxide does not exceed four parts in 10,000 parts of air, there is no noticeable harmful effect with exposures up to 1 hour. This result agrees with practical experience of the Bureau of Mines engineers with regard to the effect of carbon monoxide in mine gases, and around blast furnaces and gas producers.

Determination of Coefficients of Air Flow and Horse-Power required in Ducts, Bends and Openings.—After the first two problems with reference to the amount of carbon monoxide given off by motor vehicles and the allowable concentration had been solved, further investigations were required in determining the best method of supplying the requisite amount of fresh air which depends largely on the determination of certain factors with reference to the flow of air in ducts, bends and openings such as may be used in the tunnel. This problem is being investigated at the engineering experiment station of the University of Illinois at Urbana, Illinois, in co-operation with the engineering staff of Tunnel Commissions and the Bureau of Mines. A half-size experimental duct, 300 ft. long, has been constructed; also full-size elbows of several patterns. Many data on coefficient of air flow, useful not only for tunnel ventilation, but particularly in the metal-mining industry, have been obtained. A. C. Willard, head of the department of mechanical engineering and professor of heating and ventilating engineering, also consulting engineer for the Tunnel Commissions and the Bureau of Mines, is in charge of this work, which was carried out in accordance with the plans of Clifford M. Holland, chief engineer of the Hudson River Tunnel project.

Experimental Tunnel Investigation, Pittsburgh Experiment Station.—The final check on the solution of the three previous problems is to be obtained in the experimental tunnel that has been built in the experimental mine of the Bureau of Mines at Bruceton, Pa., just outside of Pittsburgh. An oval tunnel, or rather an underground oval track, having similar construction of ducts to those proposed in the Hudson River Tunnel, and an axial length of 400 ft., has been constructed. The cross-section is approximately 9 ft. wide and 8 ft. high. Above the ceiling of the tunnel is an air duct, 3 ft. high, and below the floor is another air duct, 2½ ft. high. Either duct may be used for introducing fresh air or for exhausting the contaminated air. The tunnel cross-section is sufficiently large to accommodate the smaller types of five-passenger cars. The tunnel is completely equipped with sensitive apparatus for measuring the temperature, humidity, quantity, velocity and pressure of the air in various parts of the tunnel. Altogether 48 air-sampling tubes are installed on eight cross-sections of the tunnel in order to obtain samples for chemical analysis, for determining the diffusion and concentration of the exhaust gases in various parts of the tunnel with different methods of ventilation.

An important feature of the experimental tunnel tests will be the comprehensive physiological and psychological observation to be made on the effects of temperature, humidity, rate of air flow, smoke and exhaust gases, on the men driving the test cars. In the tests, 10 cars will be spaced at 40-ft. intervals and will be run at the rate of 10 miles an hour; 21,000 cub. ft. of air per minute, or sufficient to maintain a concentration of four parts carbon monoxide per 10,000 parts of air by volume, will be passed across the tunnel. Each driver and observer in the tunnel will be subjected to examination before and after tests by the physicians and physiologists in charge of this part of the work. The amount of carbon monoxide absorbed by each person during the tests will be determined by examination of a few drops of blood drawn immediately after the tests. Especially sensitive methods of making these blood examinations have been developed by the Bureau of Mines. The effects of smoke and temperature on the motor-car drivers are also important considerations.

It is believed that this underground tunnel in the experimental mine has important advantages over any above-ground model, in that it more nearly represents actual conditions that will prevail in the proposed vehicular tunnel under the Hudson River. Situated as it is, about 130 ft. below the surface of the ground and 1,050 ft. in from the pit mouth of the mine, it will have a constant temperature and be free from the wide temperature fluctuations and unavoidable leakages of air in an above-ground model. The ground temperature surrounding the tunnel is nearly the same as that underneath the Hudson River. Means are installed for heating and humidifying the air to any of the conditions that may occur on the hottest summer day.

In conclusion, the studies to be conducted in the experimental tunnel are briefly summarised as follows: (1) The diffusion of exhaust gases in the cross-section of the tunnel by transverse ventilation, bottom to top, and top to bottom; (2) temperature and smoke conditions as affected by the operation of motor cars; (3) physiological and psychological effects of temperature, exhaust gases and smoke under operating conditions; (4) final check on all previous investigations, and practical demonstration of the solution of the problem of ventilating tunnels traversed by motor vehicles.

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† Superintendent, Pittsburgh experiment station, United States Bureau of Mines.

‡ Chief coal-mining engineer, Pittsburgh experiment station, United States Bureau of Mines.

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A. C. Fieldner, A. A. Straub, and G. W. Jones, "Gasoline Losses Due to Incomplete Combustion in Motor Vehicles," United States Bureau of Mines, Reports of Investigations, March, 1921, Serial No. 2,225, reprinted in *Jour. Ind. and Eng. Chem.*, January, 1921, vol. xiii, page 51.

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Platinum in Westphalia.—That the distribution of platinum is far more general than is usually assumed was mentioned by Professor J. W. Gregory, of Glasgow, in the course of his lecture on the "Genesis of Ores," delivered before the Chemical Society on December 6. In Westphalia platinum occurs associated with sandstone and argillite in a matrix of graywacke. A ton of graywacke contains up to 25 grammes of platinum, 6 of iridium, 3 of rhodium and 270 of silver. These products are sufficiently valuable, but the washing machinery is very complicated; plant is now being put up at Olpe and Warstein.

Wireless Telegraphy in Sweden.—The first Swedish wireless telegraph station for navigation was officially opened at Vinga, off Gothenburg, on November 15, states H.M. Minister at Stockholm, who adds that three other similar stations are being planned. The wireless station is intended to facilitate the navigation of vessels calling at the pilot station off Gothenburg, and of all vessels in the Skagerack passing Skagen. It has a radius of over 100 nautical miles. The wireless reports from Vinga will be transmitted free of charge for the present. The Swedish Government has recently approved proposals made by the Swedish Pilotage Board for co-operation between countries on the North Sea and the Baltic in regard to ice signalling by wireless. According to press reports in Sweden, the proposals to which effect was to be given at the close of November, comprise a scheme for reports covering the entire Swedish coast from Haparanda to the Norwegian frontier. These wireless reports regarding the condition of the ice were to be issued daily in cypher, the key to which is being published in the Swedish Notices to Mariners. The wireless messages are also to include information regarding wrecks, the withdrawal of lightships, and with regard to the presence of obstacles to navigation.